

1954

WESTERN AUSTRALIA

REPORT

of the

GEOLOGICAL SURVEY

FOR THE

YEAR 1951

[Extract from Mines Department Annual Report]

PERTH:

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ANNUAL PROGRESS REPORT OF THE GEOLOGICAL SURVEY BRANCH OF THE
MINES DEPARTMENT FOR THE YEAR 1951.

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Annual Progress Report of the Geological Survey of Western Australia for the Year ended 31st December, 1951.

The Under Secretary for Mines,

I have the honour to submit, for the information of the Honourable the Minister for Mines, my report on the operations and progress of the Geological Survey for the year ended 31st December, 1951.

The work of the Geological Survey was carried out by 11 classified officers consisting of the Government Geologist, seven geologists and three office staff.

Availability of Geologists.

Period.	No. of Geologists available, including Govt. Geologist.	Area of State.	Square Miles per Geologist.	Population.
1951.		sq. miles.		
Jan.-Feb.	7	975,920	139,410	570,000
Feb.-Dec.	8	....	121,990	....

FIELD WORK.

Major Field Work completed during the Year and in Progress as at December 31.

(1) The field work in connection with the detailed economic geological survey of an area of approximately 2,000 square miles of country surrounding the City of Perth was completed in September, and drafting work on the maps was still in progress at the end of the year.

(2) An extensive water bore-site selection programme on Cattle Stations in the East and West Kimberley Divisions was commenced and completed.

(3) Supervision of deep drilling and shallow percussion drilling on the Collie Coal Field continued throughout the year.

(4) Work was commenced on the collection of a representative suite of samples of gold bearing ore from various depths on the principal lodes of the main operating gold mines of the Golden Mile, Kalgoorlie. It is intended to submit this material to the Mineral Section of the Government Chemical Laboratories for research into mineral content and order of deposition, in order to see if any relation exists between mineralisation and attitude of ore bodies.

(5) A large number of bore-sites for water were selected on the Esperance Plains, north of Esperance, in a programme designed to investigate the underground water prospects of an area likely to be suitable for certain types of agriculture. This work was done in collaboration with the Department of Agriculture, and entails close supervision in the coming year. The Geological Survey has control of the drilling operations.

(6) A detailed geological survey of about 4,500 square miles of the Phillips River Goldfield was commenced in November.

PUBLICATIONS.

Issued during 1951.

Annual Progress Report of the Geological Survey of Western Australia for 1948.

Bulletin No. 103: Geology of Portion of the Mt. Margaret Goldfield, by R. A. Hobson, B.Sc. (Hons.) and K. R. Miles, D.Sc. (text only).

Mineral Resources of Western Australia Bulletin No. 5: Moulding Sands of Western Australia, by K. R. Miles, D.Sc. and H. A. Stephens, B.Sc. Geological Sketch Map of Western Australia, Scale 40 miles equals one inch, in two sheets.

In the Press.

Annual Progress Report of the Geological Survey of Western Australia for 1949 and 1950.

Bulletin No. 95 (3rd Edition): The Physiography of Western Australia, by J. T. Jutson, B.Sc., LL.B.

Bulletin No. 105: The Collie Mineral Field, Part I, by J. H. Lord, B.Sc., F.G.S.

Bulletin No. 103: Atlas No. 1 and Atlas No. 2 (text issued).

Compiled and Awaiting Authority to Print.

Bulletin No. 107: A Re-Survey of the Coolgardie District, W.A., by J. C. McMath, B.Sc. (Hons. Lond.), F.G.S., M. Aust. I.M.M., and N. M. Gray, B.Sc.

Mineral Resources of Western Australia Bulletin No. 6: Silver Lead and Zinc, by W. Johnson, B.Sc. (Hons.).

Mineral Resources of Western Australia Bulletin No. 7: Vermiculite, Talc and Soapstone, Fuller's Earth, Bentonite, and Diatomite, by W. Johnson, (B.Sc. Hons.).

Bulletin No. 108: The Geology of the Irwin River and Eradu Coal Basins, by W. Johnson, B.Sc. (Hons.), J. S. Gleeson, B.Sc., and L. E. de la Hunt, B.Sc.

In Course of Preparation.

Maps in connection with the Economic Geological Survey of the Metropolitan Area.

As this report demonstrates, a large amount of work has been performed during the year by both the field and office staffs, and my thanks are due to all members of the staff for their contribution, and to the Under Secretary for Mines for administratively facilitating our work.

H. A. ELLIS,
Government Geologist.

18th January, 1952.

REPORT ON STOCK WATER SUPPLIES— MOOLA BULLA NATIVE STATION—EAST KIMBERLEYS.

Approximate Latitude 18° 12' S.
Approximate Longitude 127° 29' E.

By H. A. ELLIS, B.Sc., A.O.S.M.,
Government Geologist.

Introduction.

Moola Bulla Native Station is owned by the Native Affairs Department of the Western Australian Government, and constitutes an Aboriginal Reserve of some 1,123,500 acres. It carries a large number of beef cattle, and under normal seasonal conditions despatches about 1,800 bullocks by road to the Wyndham Meat Works each year. The

station homestead is situated near the south-eastern corner of the reserve in approximate Latitude $18^{\circ} 12' S.$ and approximate Longitude $127^{\circ} 29' E.$, some 23 miles by road a little north of west from Halls Creek township, and four miles a little south of west from Mt. Barrett, a dominating landmark in the area.

In recent years the several managers have been endeavouring to locate additional water supplies by boring with a 6in. percussion boring plant, and as a result of representations made by Mr. McBeath, the present manager, to the Native Affairs Department for some geological guidance in this search, the Geological Survey was asked to help. Accordingly, the writer visited the station between 29th May and 4th June and accompanied by Mr. McBeath made wide reconnaissances of the south-eastern portion of the station in a Land Rover (4 x 4) motor vehicle. Approximately one-third of the total area was inspected in these reconnaissances, but this was the area in which additional artificial water supplies are urgently needed.

General Geology and Topography.

Moola Bulla Station occupies an area of Precambrian rocks consisting predominantly of granite, grano-diorite, steeply-dipping schists, slates, and quartzites of Archaean age, overlain by remnants of quartzites and shales belonging to the Nullagine system of Proterozoic age. The area concerned in this report contains only relatively small areas of horizontally-bedded sedimentary rocks of Nullagine age, and even smaller remnants of steeply-dipping schists, slates and quartzites of the Mosquito Creek series. The dominating rock type is granite or grano-diorite, though a more extensive development of the Nullagine series can be seen in the distance in the north-western part of the station, outside of the area under review.

The topography is essentially of low relief, consisting of large flat, to gently undulating plains, in which wide drainage valleys develop, forming gum-lined creeks with steep banks up to 12ft. or more high in places, and low hilly areas consisting of broken granite knolls or ridges. Some quartzite ridges flanked by granite form conspicuous features, and narrow remnants of the Nullagine series occur as long narrow ridges in the higher parts of the area.

Over much of the plain country the granite forms a rock floor, being covered by a few inches of soil only, revealing its presence in numerous fresh, bare, flat outcrops or prominent fresh, rounded bouldery masses. In some plain areas the soil thickness appears to be greater and gives the impression that the underlying granite may be decomposed for a considerable depth. Several exploratory water bores in this class of country revealed the fact that this was not the case, however, and generally speaking, the flat to undulating plain country carrying only a scattered growth of small eucalypts and either spinifex or other grasses, is underlain at a very shallow depth by comparatively fresh granite.

Alluviated (or "built-up") areas favourable for the accumulation of underground water are remarkably scarce, but several were located a long distance away from existing drainage channels.

The wide drainage basins have unquestionably been developed in the softest part of the granite terrain, for it is mainly in the creek beds and in the immediate vicinity of their banks that any decomposed rocks are found. This has an important bearing on the occurrence of underground water in this area.

Much of the station country lies at an elevation of 1,400 feet and more above sea level, and forms the watershed between the headwaters of the Ord and Fitzroy rivers. The average annual rainfall is about 20in., which is received mostly in the "wet" season, November to April inclusive. The large creeks and their tributaries are carrying the products of normal natural erosion (and artificial erosion caused by thousands of cattle crowded round permanent artificial and natural water supplies) down to the lower country in their beds during floods, and are not building up alluvial flood plains. Even the flood plains of some of the major creeks are rock floors with a thin veneer of soil only.

From the above description, it will be seen that the large areas of comparatively fresh granite, and the absence of alluviated (or "built-up") ground, combine to make the search for underground water somewhat difficult, and narrows the chances of success in the search for it to the prospects associated with certain restricted natural features, which will be discussed later.

The Water Supply Problem.

The problem on this station, as on all stations, is to provide reliable artificial water supplies of sufficient capacity to augment the natural permanent water supplies (mainly large water holes in the main creeks) and to locate them in such positions as to use the maximum area of country with the minimum amount of erosion caused by stock coming into and going out from water.

The amount of erosion caused by cattle when large numbers of them use one water supply has to be seen to be believed. Hundreds of acres are literally turned into dust heaps and all the feed is eaten out for miles around the water point.

Unfortunately, only very rarely is nature so kind as to provide conditions whereby artificial water supplies can be provided from underground water sources exactly where desired.

In the area under review, namely, the south-eastern portion of Moola Bulla Station, a limited number of artificial water supplies in the nature of wells have been provided. These wells are located on the banks of large streams or near the drainage channel in wide, open, shallow head-water basins. They have been sited in positions which observation and experience proves to be the right localities for obtaining water in this class of topography.

Unfortunately, where water is most urgently needed in this part of the station, these conditions are not repeated. If they had been, there would have been no necessity for geological advice in the present search for water, as the present station manager is as well able to detect these prospects as is the writer.

Another important aspect is that an artificial water supply intended for the watering of cattle running in unfenced country must be capable of producing at least 10,000 gallons of water per 24 hours, and it must be able to do this during the six months of the year following the drying up of the natural surface waters after the wet season, and the beginning of the rains in November, and longer if the rains are late.

These are exacting requirements and require exacting geological conditions to meet them. In the writer's experience, no single 6in. bore hole drilled into the rock-types known to occur on this station is likely to have this capacity, irrespective of how favourable the site is. Recourse must be had to the well and drives to produce this quantity of water in metamorphic rocks, and the well must be so situated that the underground reservoir is rapidly recharged each year when the rains come.

A small number of exploration percussion boreholes have been drilled in recent years on sites in the areas where additional water supplies were required, but they either failed to find water or were unable to produce the necessary quantity of water. Some of them have been equipped with windmills, tanks and troughing, only to be abandoned shortly after completion.

The geological characteristics of the country in which these unsuccessful bores were sunk were explained to the manager on the site, and it was clear that useful water supplies could be found in this country under only two sets of conditions, namely—

- (a) alongside main creeks;
- (b) in higher level "built-up" areas containing a considerable thickness of soil overlying a deeply weathered rock zone.

These higher level "built-up" or alluviated areas are scarce on this station, but one had been located and prospected by a borehole. This hole penetrated 151ft. of soil and decomposed granodiorite before it was stopped in fresh granodiorite. A bailing test at the rate of 400 gallons per hour failed to lower the level of the water when applied for a quarter of an hour. Water was struck at 120ft. and rose slightly in the bore.

This type of potential aquifer (water-bearing rock) can be detected by the absence of outcrops or large quartz grains in the soil, the presence of a light powdery soil and a prolific growth of grass, not spinifex. The gum trees (eucalypts) are considerably larger and more numerous than on country which has only a thin mantle of soil and a shallow zone of decomposition.

Although this is an encouraging water occurrence, its value cannot be gauged until it has been subjected to a continuous pumping test for at least 24 hours. Should this class of aquifer stand up to this test and produce its 10,000 gallons, there will be a strong tendency to equip it as a borehole supply, but the writer has no faith in the 6in. boreholes in this class of country being able to stand up to a six months daily draw of 10,000 gallons per day.

A borehole capable of delivering 10,000 gallons in 24 hours without a very serious fall in the level of the water table is an excellent prospect on which to sink a well and provide additional storage by driving from the bottom of the shaft. The provision of a reliable water supply of adequate quantity is creating an asset of very great value in this country, and the cost of first sinking the bore, then sinking a well on the bore and driving from the bottom of the well and subsequently equipping the well with pump, tanks and troughing, is small compared with the ultimate financial gain connected with increased carrying capacity and the more even distribution of the herd over the property.

Recommendations.

(1) The search for water in the south-eastern part of the Moola Bulla Native Station should be confined to two topographic positions, namely:—

(a) Main drainage channels and wide head-water basins occupied by smaller creeks.

(b) Higher level alluviated or "built-up" areas.

(2) Exploration should be by 6in. percussion boring in the first instance, and on a satisfactory 24-hour pumping test being established, a well should be sunk on the bore and drives extended from the bottom of the well.

(3) Boring should not be continued in fresh rock if the upper soil and decomposed rock have failed to provide a water supply adequate to requirements.

(4) In the peculiar circumstances applying to the East Kimberleys, where it is virtually impossible to get contract borers with their own boring plants, and a lot of exploration is necessary to test the water bearing capacity of a huge area of country, it is highly desirable that the station should have a boring plant of its own. This plant should be operated by wages personnel, under a bonus system

of so much per foot for distance drilled. This principle is followed by the South Australian Government with marked success.

(5) An eminently suitable type of boring plant is an all steel, diesel driven unit, mounted on pneumatic tyres as a trailer unit. Such a plant as the Ruston-Bucyrus 22W. well drill should be ideal for the class of country encountered on Moola Bulla Station. This type of drill is in extensive use in South Australia, and has been proved to be particularly suitable for outback conditions. This machine has a drilling range of 16in. diameter holes to a depth of 100ft., down to 6in. diameter holes to a depth of 750ft.

PEAK HILL GOLDFIELDS MANGANESE DEPOSITS.

10th July, 1951.

The Under Secretary for Mines:

In June of this year I inspected the principal manganese occurrences known to the Mines Department in the Peak Hill Gold Field.

2. My investigations were confined principally to ascertaining the mode of occurrence of the deposits, i.e. to determining whether they were lode formations or surface cappings over completely barren rocks.

3. I unhesitatingly proclaim them to be surface cappings over barren rock, and to be formed by the replacement of pisolitic, bauxitic material of an old land surface.

4. The manganese and iron have been provided from adjacent higher country in solution in drainage waters. The rock type carrying the manganese in trace quantities is a hematite-rich sandy shale of the Mosquito Creek Series, found in the higher country adjacent to the deposits.

5. Mining operations (quarrying) have made many exposures of bed rock, and these combined with natural exposures provide convincing evidence of the shallow nature of the deposits.

6. There is absolutely no necessity for any exploratory drilling of these deposits, either by churn or diamond drilling.

7. If further sampling is required this could be best done by digging pits, using a portable compressor.

8. Would you please pass a copy of this minute together with my ore reserve estimates to The Director of the Bureau of Mineral Resources, 485 Bourke Street, Melbourne.

H. A. ELLIS,
Government Geologist.

MANGANESE ORE DEPOSITS—PEAK HILL GOLDFIELD, W.A.

Summary of Estimate of Ore Reserves.

Deposit.	*Tonnage containing 42 per cent. and more of Mn.	†Tonnage containing under 42 per cent. Mn.	Remarks.
Northern Deposit, Horseshoe	Long tons. 30,000	Long tons. 62,000	Some guessing and judgment had to be used in this estimate. Analytical data reliable. Estimate reliable: based on sample pits. Analytical data reliable. Some guessing and judgment had to be used in this estimate. Analytical data reliable. Known to be small and not considered to have any appreciable effect on the total reserve situation.
Southern Deposit, Horseshoe	215,000	245,000	
M.C. 30P, Mt. Fraser Locality	18,000	18,000	
Other deposits ....	....	....
Totals	263,000	325,000	

* Maximum Mn content probably 55 per cent.

† Minimum Mn content probably about 24 per cent.

PEAK HILL G.F. MANGANESE ORE RESERVES.

By H. A. ELLIS, Government Geologist.

Horseshoe Manganese Deposits.

(1) The Southern Deposit. M.C. 24P.

Based on Blatchford's sampling and mapping (G.S.W.A. An. Rep. 1929) and a recent examination of the deposit by the writer (June, 1951), the following is an estimate of ore-reserves for this deposit:—

Original Area of Manganese Ore = 12 acres.

Sampled by 40 sampling pits from 2 to 20 ft. deep.

Average depth 11 feet (the average of 40 sampling pit depths).

Average grade = 39.8% Mn, (determined from analyses of 136 samples),

Estimate of Quantity of Manganese Ore of Average Grade of 39.8 per cent. Mn.

Area = 12 acres = 43,560 × 12 sq. feet.

Average depth = 11 feet.

Volume of ore = 43,560 × 12 × 11 cubic feet.

Tonnage (using 10 cubic feet = 1 long ton) = $\frac{43560 \times 12 \times 11}{10}$ = 574,992 tons.

Less 20% for cracks, cavities, and irregularities in base and top of ore body—

574,992
—114,998

459,994 tons.

or, say: 460,000 tons.
Less what has been mined to date (July 1951). 15,000 tons.

= 445,000 tons.

Estimate of Quantities of Manganese Ore of Various Grades Contained in the Deposit of 445,000 tons of Average Grade of 39.8 per cent. Mn.

In Blatchford's detailed sampling (G.S.W.A. An. Rep. 1929) the ore was divisible into a number of areas (eleven) which could be further placed into three groups in which the average manganese content was 50.7%, 45.7% and 42% respectively. His estimated tonnages for these grades (exclusive of what has been quarried over the last three years; 15,000 tons) are as follows:—

	Tons.
Ore containing 50.7% Mn.	73,500
Ore containing 45.7% Mn.	75,500
Ore containing 42% Mn.	66,000

Ore containing 42% to 50.7% Mn. = 215,000

Ore containing less than 42% Mn. = 460,000–215,000
= 245,000

Analytical Data.

Ore containing 50.7% Mn. contains	73.3% MnO ₂ 6.3% Fe 0.98% SiO ₂
Ore containing 45.7% Mn. contains	68.4% MnO ₂ 9.35% Fe 1.45% SiO ₂
Ore containing 42% Mn. contains	14.4% Fe 2.4% SiO ₂

A complete analysis of a sample from 11 mixed samples is as follows:—

	Per cent.
MnO ₂	66.32
MnO	6.04
Fe ₂ O ₃	14.59
SiO ₂	0.90
CoO	0.23
NiO	Nil.
BaO	0.62
K ₂ O	1.97
Na ₂ O	0.30
CaO	Nil.
MgO ....	.25
Al ₂ O ₃	2.43
TiO ₂	0.12
CO ₂	Nil.
P ₂ O ₅	0.17
SO ₃	0.25
H ₂ O above 100°	5.76
H ₂ O at 100°	0.67
	<hr/> 100.62

On Dry Ore..

Total Mn	= 46.90%
Fe	= 10.28%
P	= 0.074%
S	= 0.101%

Analysis by Geological Survey Laboratory 1925.

Typical analyses of three parcels of ore mined in 1948 and assayed by Broken Hill Pty. Ltd. are as follows:—

	Mn.	Fe.	SiO ₂ .	P.	H ₂ O.
895.59 tons;	48.98	8.66	0.21	0.094	0.70 (per cent.)
2,131 tons;	50.40	8.50	2.50	0.08	0.90 (per cent.)
2,238 tons;	47.47	9.86	1.47	0.035	0.50 (per cent.)

The average Mn. content of 12,766 tons of ore shipped during 1948, 1949 and 1950 is 47.47 per cent.

Analyses of ore containing less than 42 per cent. Mn. show Mn. values as low as 24 per cent, and Fe as high as 34 per cent. with SiO₂ up to 2.82 per cent.

(2) The Northern Deposit.

This deposit is situated about one mile north of the Southern Deposit. It has not been sampled in detail and has not been worked. The following estimates of ore reserves and grade are based on Montgomery's plan and analyses (1925) and a personal inspection of the deposit by the writer in June, 1951.

Area of Manganese Ore = length by average width (16 widths) = 1,200 ft. × 171 ft.

Average thickness—5.6 ft. (average of 5 observed thicknesses).

Volume of ore = 1,200 × 171 × 5.6 cubic feet.

Tonnage (using 10 c. ft. = 1 long ton) = $\frac{1,200 \times 171 \times 5.6}{10}$ tons.

= 114,912 tons.

Less 20 per cent. for cracks, cavities and irregularities in base and top of ore body—

114,912 tons
—22,982

91,930 tons

or say: 92,000 tons.

Four samples taken across the surface of the ore-body by Montgomery at roughly equal intervals over its length gave the following results:—

- 49.99% Mn. over a sample length of 350ft.
- 47.01% Mn. over a sample length of 300ft.
- 48.32% Mn. over a sample length of 60ft.
- 52.40% Mn. over a sample length of 60ft.

This gives a weighted average of 48.89% Mn.

Details of the above analyses are as follows:—

	H ₂ O—	Mn.	Assay on Dry Ore.			
			MnO ₂ .	MnO.	Fe.	SiO ₂ .
(a)	0.60	49.99	75.54	2.91	6.63	0.54
(b)	0.65	47.01	69.94	3.63	8.69	0.85
(c)	0.85	48.32	72.24	3.44	6.12	1.01
(d)	0.74	52.40	78.34	3.75	3.48	0.57

After inspecting the ore body, the writer guesses, in the absence of detailed pit sampling, that approximately one third of the available ore would contain 42% or more of manganese.

The ore reserves can be dissected as follows, based on the above guess:—

42% or more of Mn.	....	30,000 tons
Under 42% Mn.	....	62,000 tons

The Northern ore body has the same structure and mode of occurrence as the Southern ore body, i.e. it is a superficial deposit consisting essentially of hard psilomelane and limonite in varying degrees of purity, and has no possibility whatever of downward continuation.

(3) M.C. 30P., 3½ miles West of Mt. Fraser.

This deposit is 20 miles S.W. of "Horseshoe" and has been worked during 1949 and 1950 by the Broken Hill Pty. Coy. Ltd.

It has the same structure and mode of occurrence as the "Horseshoe" deposits, and was examined by the writer in June 1951.

The area which has supplied Wiluna Township and the Wiluna Gold Mine with potable water at the rate of one million gallons a day for 13 years, without permanently lowering the water table, is an old drainage system now filled with fluvialite terrestrial sediments, and forms part of the large Lake Way salt lake catchment area. It has a north-south trend with a width of about five miles in an east-west direction measured along the Lake Violet Station road, commencing at a

point approximately three miles east of Wiluna. The country gradually rises east and west and consists of either granite or greenstone. The northern divide is a series of 'breakaways' in spinifex country about 35 miles north-east of Wiluna along the road to Cunyu Station. The underlying rock is here composed of granite and gneiss. From ground and air reconnaissance, the latter made possible by the courtesy of Mr. M. Finch, a local station owner who flew the writer over the area in an Auster monoplane, it is clear that this wide, flat to undulating drainage area is supplied with the bulk of its water from the two intermittent creeks Negrara Creek and Kukabubba Creek, which drain the higher country occupied by the Nullagine Series north and north-west of Wiluna.

The northern limit of the drainage area is definite at about 35 miles north of Wiluna, but the north-eastern limit was less easy to define with the transport available. The eastern side could be recognised both on the ground and from the air. There is no well marked creek entering from the north-east, but it is probable that a series of flat alluviated drainage areas come in off the granite country in this direction.

The depth of the built-up ground has not been determined in any part of this basin, as is evident from an inspection of the dumps of over 40 wells located in it, and P.W.D. bore log records of the bores sunk at the Peanut Plantation, seven miles east of Wiluna.

The area of built up ground consisting of fluvial sediments within the catchment area of approximately 547 square miles could not be determined in a reconnaissance survey, but it is considerable. Ground reconnaissance suggests that there is a long low tongue of flat to undulating granitic country extending well down into the basin from the north, dividing the drainage of the Kukabubba and Negrara Creeks, out on the seemingly flat alluviated basin.

South of the Wiluna-Lake Violet Station road, the width of the alluviated basin increases, and for a distance of three miles south of this road, ground water has been found in large quantities, and has been proved suitable for vegetable growing.

The general shape of the catchment area is an immense fan extending 35 miles north from the Wiluna-Lake Violet Station road, with a maximum width or spread of about 35 miles, gradually contracting southwards to about five miles wide and then gradually opening up. Within this fan-shaped area there are large areas of fluvial sediments occupying old depressions in a now buried terrain, which was itself an old drainage channel. These sediments are the storage ground for the waters poured into them from large creeks such as Negrara and Kukabubba Creeks, and themselves readily absorb rainfall. The absence of any defined incised drainage channel (creek) crossing the Wiluna-Lake Violet Station road within the basin eastwards from Wiluna is significant when it is realised that the drainage from 547 square miles of country has to ultimately reach the Lake Way Salt Lake System. Torrential rains cause extensive sheet flooding of this area, and no doubt there are shallow, wide depressions on this apparently flat part of the basin, which would be in evidence as surface water carriers after exceptionally heavy rains.

The shape in depth and laterally of the alluviated basins is unknown at present, but their water-yielding capacity is known in three localities, viz., at the Town Well Reserve No. 21,142, situated four miles east of the Wiluna P.O., the Wiluna Gold Mine well area situated 1.7 miles south of the Town Well Area, and the Peanut Plantation situated about seven miles east of Wiluna.

The nature of the fluvial sediments, as revealed from the dumps of the wells, indicates the occurrence of white indurated clays, thick (up to 12ft.) bands of opaline silica with associated friable soft opaline silica full of drussy cavities, ferruginous grits cemented with lime and containing some opaline silica in thin bands, loose sand and small waterworn pebbles of ironstone and quartz.

No reliable information is available about which beds carried most water, and in only one instance is the occurrence of sub-artesian water (pressure water) recorded.

Water level is approximately 12 feet below ground level at most wells, but it is obvious that this water must have a surface gradient which will be from north to south. No data are available about the reduced levels of either water level or ground surface level at the various wells.

The full water yielding capacity of a complete vertical section of the fluvial sediments is not known, because the deepest well is 47 feet and the deepest bore is 40 feet, and neither wells nor bores have penetrated to true bedrock, which is either granite or greenstone.

Capacity Data.

Assuming an average annual rainfall of 980 points, the catchment area of approximately 547 square miles (350,000 acres) north of the Lake Violet Station road would receive about 76,580 million gallons of rain water per annum. Assuming that only one-third of this quantity of water was absorbed and stored in the fluvial sediments as underground water, then each year an average of approximately 25,000 million gallons of water would go underground. This quantity of water must be presumed to be moving southwards across the narrower southern end of the basin on an average, each year. This could account for the fact that the continual withdrawal and complete removal from the basin of 365 million gallons of water per year for 13 years made no impression on the level of the water table.

This water was drawn from the Town Well group, and the Mine Well group in approximately equal quantities of 500,000 gallons per day each. The Town Well group consists of 10 wells, the maximum depth being 35 feet, the length five feet and the width four feet. There is no reliable information about the maximum capacity of any of these wells, but an average yield of 50,000 gallons each per day must have been obtained to meet the 500,000 gallons per day which is reliably quoted as the daily consumption for many years. The material in the dumps of these wells is mostly opaline silica, both massive and friable, and locally called "opaline" limestone. No details are available about the manner in which the water enters the wells. Water level stood at about 12 feet below ground level in August, 1951.

The group of 10 wells is distributed over an area 72 chains long east and west by 15 chains wide north and south, but no information is available about any interference of one well with another near by, during pumping operations.

It is clear that this area has not ever been fully exploited, because none of the wells has penetrated to bedrock and from the appearance of the dumps, none of them has any drives at the bottom.

The water from these wells has been used for some 13 years on lawns, vegetable gardens and citrus fruit trees without noticeable injury to plant life.

One analysis of the water from the storage tanks of the town water supply gave 49 grains of total salts per gallon of which nine were sodium chloride and the p.H. reaction was eight.

The Mine Well group is situated about 1.7 miles south of the Town Well group and three and a half miles east of the Wiluna Gold Mine. The wells have been sunk through opaline silica and ferruginous grits to an average depth of 47 feet, with drives 50 feet long east and west at the bottom. Some 18 wells occur in an area 1.4 miles long in an east and west direction and about 30 chains wide in a north and south direction. No detailed information is available about the yields of the individual wells or how the water entered them. Water level in August, 1951, stood at about 12 feet below ground level and the group maintained a steady daily supply of about 500,000 gallons of water for 13 years without permanently lowering the water table.

Mr. H. H. Carroll, general manager of Wiluna Gold Mines for many years, told the writer in August, 1951, that once during the active life of the

mine when the daily draw from these wells was 500,000 gallons per day, the electric pumps had to be lifted four feet on account of the gradual rise in the water table some months after heavy rains had fallen to the north. If the rain fell within the catchment area of the basin, then such a rise could be expected, but there is a legend that the rain fell hundreds of miles to the north, and still affected the basin. This is a good basin, but not quite as good as that.

The Peanut Plantation Area is situated about seven miles east of Wiluna on both sides of the Wiluna-Lake Violet Station road. Here a number of shallow wells have been sunk through ferruginous grits to a water-table 12 feet below ground level. This area is continuous geologically with the Town Well and Mine Well areas, and draws water from the same wide-spread saturated zone of fluviatile sediments. Varying yields have been experienced in the wells here, but as in the other two areas, the potentialities of the aquifer have not been anywhere near fully tested. Some figures are available from a series of bores put down by the Public Works Department on experimental plots during 1949-50 in connection with the Wiluna Peanut Project. They have been made available by the Goldfields Water Supply Branch and appear in Appendix 1.

It will be seen from these details that the maximum depth of any bore was 40ft.-3in. and that yields of up to 3,600 gallons per hour of water containing from 24 to 84 grains of total salts per gallon were obtained without a maximum yield having been determined. It will also be observed that in several instances continuous pumping at the rate of 3,600 gallons per hour for eight hours failed to increase the total salinity of the water or to seriously lower the water table.

Some details are available about the capacity of one well used as a source of irrigation water on the peanut plantation. A 6ft. by 4ft. well 20ft. deep sunk in ferruginous grits, with two 5in. bore holes 10ft. deep sunk in the bottom, was put under pumping test. The well was pumped for 23 hours per day for seven days at the rate of 5,000 gallons per hour. The water level was gradually lowered by pumping at a rate in excess of 5,000 gallons per hour, when it became evident that water was entering the well almost exclusively up the two bore holes in the bottom. The level could not be lowered at rates less than 5,000 gallons an hour, and no variation in this flow was noticed in practically one week of continuous pumping. This water was obviously under pressure, but not sufficient to cause it to flow at the surface. The aquifer must have been some loosely consolidated sand or grit, because it has a phenomenally high rate of yield. The question of whether there is pressure water in the basin elsewhere also arises, and it is not beyond geological possibilities for shallow artesian water to occur in this type of sedimentation.

Characteristics of Fluviatile Basins.

It was not possible in a reconnaissance examination of the Wiluna Basin to even approximately determine the area occupied by fluviatile sediments, but the area in which soil, topographic and vegetation conditions appeared similar to those in the vicinity of the three proved water bearing localities east of Wiluna is large, amounting to many thousands of acres.

The grain size and mineral composition of fluviatile sediments is inherently subject to quick lateral and vertical variation, being likely to be coarser near the principal feeding creeks and along the edges of the basin.

The basement rock is likely to be disposed in wide undulating surfaces, and to be covered by sediments of different water yielding capacities in different parts of the area.

It will be obvious, therefore, that we cannot expect to encounter the same water-productive capacity over the whole of the alluviated area, and that much experimental boring would be necessary to locate areas of maximum yield.

It is also certain that to properly exploit any of these potential high water yielding areas, bores must penetrate to hard bed-rock, which will be either granite or greenstone; probably mostly granite. The salinity of water derived from the sediments low down in the fluviatile sedimentary succession will need careful checking, because it is possible for water of a higher salinity to occur in the beds below a zone of low salinity water.

There may be areas of built-up ground within this basin, on which the soil conditions are similar to known high water-yielding areas, but which could have only a comparatively thin layer of sediments covering underlying bedrock, and on which poor ground-water yields would be obtained.

As previously mentioned, there may be also considerable areas in which pressure water may be found, giving rise to either sub-artesian or even possibly artesian water conditions. These areas can only be found by actual exploration.

Conclusions.

(1) A large depression filled with water-bearing fluviatile sediments exists immediately East of Wiluna.

(2) The catchment area of this basin, North of the Wiluna-Lake Violet Station Road, has an area of approximately 547 square miles or 350,000 acres.

(3) The relative areas of exposed basement rock and built-up (fluviatile) ground within this catchment area are not known, but the area of ground on which soil, vegetation and topographic conditions appear similar to those of known high water yielding areas east of Wiluna amounts to many thousands of acres.

(4) For a period of 13 years, two groups of wells situated approximately four miles east of Wiluna, withdrew continuously a total of 1,000,000 gallons of water per day from the southern end of this basin, without permanently lowering the water table or noticeably increasing the salinity of the water.

(5) The water from this basin was used exclusively on vegetable market gardens, lawns and citrus fruit trees on both residual and transported soils and yielded excellent crops. Peanuts have been successfully grown also, using water from the same source.

(6) The total salinity of the water varies, the maximum recorded being 84 grains per gallon. One analysis of the town water supply in 1935 gave a total salinity of 49 grains per gallon of which nine grains was sodium chloride (salt).

(7) The full water-yielding capacity of any part of the basin has never been tested, and the highest reported yield from any one well was 115,000 gallons per 24 hours for a continuous period of seven days, the water level remaining steady during the test.

(8) Exploration of the basin to bedrock by percussion drilling in the first instance, has excellent prospects of producing large quantities of water in subsequent exploiting wells, suitable for irrigation purposes.

(9) The initial determination of the shape of the bottom of the basin in any selected area, appears to lend itself to solution by geophysical electrical resistivity methods of prospecting.

Recommendations.

(1) In order to use this natural water resource as a possible reviver of a district which has suffered a severe decline in population through the closure of the Wiluna Gold Mine, it is suggested that some steps may be taken to ascertain if it is possible both physically and economically to produce any crops under irrigation using the underground water from the Wiluna Basin.

(2) In view of the excellent prospects of obtaining sufficient quantities of suitable water over perhaps large areas of this basin, consideration may ultimately be given to the establishment of an experimental area by the Agricultural Department. Should this eventuate, then the Geological Survey would be pleased to co-operate in the selection of the area, and in the development and exploitation of the underground water resources.

Appendix to Government Geologist's Report on Wiluna Water Supply.

WILUNA PEANUT PROJECT.
Results of Boring for Water (by Contract).
1949-1950.

No. of Bore.	Rest Level.	Depth of Hole.	Salinity Before Pumping.	End of 1 hr. Pumping.			End of 2 hrs. Pumping.			End of 3 hrs. Pumping.			End of 4 hrs. Pumping.			End of 8 hrs. Pumping.		
				Salinity.	G.P.H.	W.L.	Salinity.	G.P.H.	W.L.	Salinity.	G.P.H.	W.L.	Salinity.	G.P.H.	W.L.	Salinity.	G.P.H.	W.L.
	ft. in.	ft. in.		g.p.g.		ft. in.	g.p.g.		ft. in.	g.p.g.		ft. in.	g.p.g.		ft. in.	g.p.g.		ft. in.
2	40 3	76	76	3,600	16 0	76	2,840	18 0	76	2,800	18 0	76	2,840	18 0	....	....	....
3	11 11	36 0	84	1,200	24 0	....	....	....	....	....	....	....	....	....	....	....	....
4	10 4	26 0	56	3,600	15 6	56	3,750	16 2	....	....	....	56	3,750	16 2	56	3,750	16 2
5	11 8	35 0	72	3,600	17 0	....	....	....	....	....	....	74	3,600	17 0	74	3,600	17 0
6	12 6	36 0	72	809	23 0	....	....	....	....	....	....	....	....	....	....	....	....
7	11 0	28 0	42	3,000	16 0	....	....	....	....	3,000	16 0	....	....	....	44	3,000	16 0
8	12 10	30 0	80	2,880	20 0	76	3,050	20 8	76	3,050	20 8	76	3,050	20 8	....	....	....
9	13 0	40 0	68	240	21 8	....	....	....	....	....	....	....	....	....	....	....	....
10	11 0	28 0	56	1,500	23 0	56	1,500	23 0	56	1,500	23 0	56	1,500	23 0	....	....	....
11	13 7	30 0	84	620	25 0	84	620	25 0	....	....	....	....	....	....	....	....	....
13	11 6	30 0	60	Pump emptied Bore in 30 seconds.					....	....	....	....	....	....	....	....	....
14	12 5	30 0	84	1,320	17 0	84	1,377	18 0	....	....	....	....	1,760	21 6	84	1,980	24 0
15	13 0	30 0	56	660	23 6	48	660	23 6	....	....	....	....	....	....	....	....	....
16	10 8	30 0	52	3,600	16 3	52	3,600	16 3	....	....	....	52	3,600	16 3	52	3,600	16 3
17	11 6	30 0	80	660	23 0	80	700	24 0	....	....	....	....	....	....	....	....	....
18	12 7	30 0	72	585	24 0	72	585	25 0	....	....	....	....	....	....	....	....	....
22	10 6	30 0	48	906	24 0	48	906	24 0	....	....	....	....	....	....	....	....	....
23	11 3	30 0	64	850	24 0	64	850	24 0	....	....	....	....	....	....	....	....	....
25	10 7	30 0	56	1,056	10 7	56	1,056	10 7	56	1,056	10 7	....	....	....	....	....	....
25A	30 0	60	1,250	24 0	60	1,250	24 0	....	....	....	....	....	....	....	....	....
26	10 7	40 0	68	900	10 7	68	900	10 7	68	900	10 7	....	....	....	....	....	....
27	9 10	40 0	58	950	9 10	58	950	9 10	58	950	9 10	....	....	....	....	....	....
28	40 0	44	2,700	....	....	....	....	....	....	....	....	....	....	....	....	....
29	37 6	68	840	....	....	....	....	....	....	....	....	....	....	....	....	....
30	10 7	31 6	24	748	25 0	24	748	25 0	24	748	25 0	....	....	....	....	....	....

No details forwarded for Bores shown on Lots 1 and 12.
Note.—Bore yields shown are not necessarily the maximum yield s pumping equipment would not, in all cases, permit of complete test.

REPORT ON NEVILLE'S SCHEELITE PROSPECT P.A. 2476, NOONGAL, YALGOO G.F.

Approximate Latitude, 28° 10" S.

Approximate Longitude 117° 00" E.

By H. A. Ellis, B.Sc., A.O.S.M. Government Geologist.

Location.

P.A. 2476 is situated about 16 miles north-north-east of Yalgoo about three-quarters of a mile west of the Yalgoo-"Carlaminda"-Meka" Road, in low rugged greenstone hills, and about two miles N.N.W. of the old Noongal Townsite and three-quarters of a mile South of Noongal Rock-Hole. The same ground has been previously held as P.A's. 2315 (1942), 2338 (1943), 2409 (1947) and 2443 (1949), all in the name of Neville.

The locality was examined with the owner, Mr. J. Neville of Yalgoo, on August 23, 1951, with a view to advising him on the best method of further prospecting the occurrence of scheelite. The prospect had been examined in 1942 by F. Forman. (An. Rep. G.S. 1942, p. 9.)

Geology.

The country rock consists of slightly schistose, massive greenstones, composed predominantly of fine to medium-grained crystalline ferromagnesian minerals of the hornblende group. The schistosity trends about N.30°W. and dips vertically, and is variable in intensity. Besides imparting a general schistosity of varying degree to the basic rocks, which appear to be lavas and not intrusives, the folding movements have been locally intense, resulting in shearing and foliation of the rocks in short, discontinuous structures, whose strikes and dips cut across the strike and dip of the regional schistosity. It is in these structures that scheelite mineralisation has taken place, with accompanying dynamic and hydrothermal metamorphism. Biotite granite outcrops in the locality, and bands of schistose granitised greenstone up to 4 feet wide extend from the granite contacts for some distance along the direction of regional strike of the schistosity, into the main greenstone mass. These are the "sheared porphyrites" referred to by the prospectors. Pegmatite dykes also occur in the vicinity.

The Principal Scheelite Occurrences.

The main known scheelite deposition is confined to three sheared and foliated structures, within an area about 12 chains long north and south by five chains wide east and west. The strikes of these shears vary from N-W. to N-E. and one has a curving strike swinging from E-W. to N-W. Dips vary from 45° to 70° and are to the west or south. The longest mineralised shear is about 2½ chains long, and the three shears have no linear connection, but are distributed in a rough echelon manner. They have been mined as open cuts to a maximum depth of about 10 feet with several shallow underlay shafts not exceeding 40 feet in length.

Lenses of chlorite schist, actinolite schist and vermiculite varying in width from seven feet to six inches occur along the shears, and are the host material for disseminated pale green scheelite grains and crystals and occasional partially crystalline masses of scheelite weighing up to 10lb. The vermiculite lenses always carry the best values.

In one of the shears a large piece of Bismuth Carbonate was found associated with the vermiculite, but this mineral is very rare in the present workings. No quartz has been seen in association with the scheelite and bismutite, and associated opaline silica and magnesite are rather diagnostic of surface expressions of potentially mineralised zones. Footwall and hanging-wall rocks are frequently medium-grained hornblende rocks with occasional strong developments of massive green actinolite rocks. The rock assemblage and shearing is very similar to that associated with the Young River vermiculite deposits in the southern part of the State, but in that locality no metallic minerals other than magnetite have been found in the vermiculite lenses.

The clayey loam near the shears carries detrital scheelite, and is obviously a source of ore. The area of this material is of small extent, however, but it would be comparatively rich. Scheelite varying in size from a fine powder up to pieces 1 inch by ½ an inch can be recovered by panning this loam.

Grade of the Deposits.

The mineralisation is extremely irregular, the scheelite being inclined to occur anywhere in a lens of chlorite schist, actinolite schist or vermiculite, in patches or as disseminated grains. The readily available soft ore has been mined to shallow depth only, downward exploration having ceased when the lens of ore narrowed to a few inches.

During 1942-43 approximately 407 tons of ore was mined and treated in a stamp-battery and concentrated on a Wilfley Table for a return of 6692lb. of concentrates, containing an average of 64.5% WO₃. This quantity of ore therefore contained about .73% of scheelite. The present day (Aug. 1951) value of the 6692 lb. of scheelite concentrates of an average grade of 64.5% WO₃ is approximately £6,480 (at £A33 10s. per long ton unit). Roughly, the 407 tons of ore contained the monetary equivalent of £16 per ton, or say an ounce of gold per ton. This comparison is drawn to attract attention to the fact that a gold deposit yielding one ounce to the ton would be vigorously prospected, yet a scheelite deposit of equivalent monetary value has been neglected. It is also very certain that many hundreds of pounds of high quality scheelite were lost as slime by treating this class of ore in a stamp battery, and the grade of the ore treated was probably close to 1% scheelite.

Future Prospects.

This scheelite occurrence has no prospects for large scale development, but the three previously worked shears, although short in length, have a production history (from two of them only) and types of structure which certainly justify at least another 100 feet of shaft sinking on each of them. With tungsten valued at £33 10s. per long ton unit (Aug. 28, 1951) of WO₃ (tungstic oxide) the risk involved in further exploring these scheelite-bearing shears is amply justified. Swelling and pinching in this type of structure is to be expected, and the downward limits of scheelite mineralisation had not been reached in any of the workings.

REPORT ON THE DONNELLY RIVER GRAPHITE DEPOSITS, W.A.

Approx. Lat. 34° 13' S.

Approx. Long. 115° 55' E.

By H. A. ELLIS, Geological Survey of W.A.

(Note.—This report should have appeared in the Annual Report Geological Survey for the year 1943 but was omitted in error.)

Locality.

These deposits are situated in hilly, thickly timbered country, on the northern side of a small easterly trending tributary of the Donnelly River, at a distance of approximately 15 miles west of Manjimup by road, in approximate Lat. 34° 13' S., and approximate Long. 115° 55' E. They are located on M.C.281H, forming part of Mining Reserve No. 12318 (See Lands Dept. Litho No. 439C/40 Square D.4.).

Manjimup is 197 miles by rail from Perth, and 90 miles by rail from Bunbury, the nearest port.

The deposits were examined on December 1st, 1943.

Topography and Geology.

With the exception of occasional small cleared farms in the broader depressions of the moderately hilly country surrounding the graphite

locality, the whole of the area is covered with thick jarrah and karri forest with dense undergrowth. The soil is the characteristic pisolitic gravelly type at the surface, with no visible outcrops, and it is only on the graphite claim which had been recently burned that any clue could be got as to the nature of the underlying rocks.

It can be gathered from evidence available here that the surrounding country is probably composed of a series of gneisses and schists.

The Graphite Deposits.

It would appear that the graphite was first detected in some ferruginous laterite capping the crest of the low timbered hill immediately north of the swampy creek at the south end of the claim. The impact of metal such as a heel plate of a boot or a horse shoe leaves a shiny mark on graphitic laterite, and this characteristic probably lead to the discovery of the graphite seams.

In 1916 these deposits were examined by the late Mr. H. P. Woodward of the Geological Survey who described them at that time as being of no commercial value on account of the amorphous nature of the graphite (G.S.W.A. file 171/16).

At the time of inspection (December 1st, 1943) nearly all of the old workings were inaccessible or unsafe to enter, and consequently only a limited amount of information as to the nature of the deposits was available.

It would appear however, with a reasonable degree of correctness, that on the southern and south-eastern slopes of the hill at the south end of the lease, and immediately north of the easterly trending swampy creek, a series of micaceous schists with bands of graphitic schist and quartzite underlies the gravelly and yellow clayey soil mantle.

From the distribution of the old workings showing amorphous clayey graphite in the dumps, the graphite-bearing zone strikes N. 70° E. and dips at 37° to the N.W. The only reliable strike and dip occurs in the shaft at the crest of the hill.

The zone as measured is at least 400 feet true thickness, with at least three well defined clayey graphite horizons of unknown thickness occurring one at the top, another some 150 feet below it, and the third near the base of the zone. The state of the workings did not anywhere permit of a true thickness of the seams being measured.

No information was available to indicate for sure the extent of these seams along the direction of strike. The top seam has been cut in a vertical shaft 13 feet deep now partially collapsed, which shows on the S.E. end of the shaft a vertical section consisting of six feet of red concretionary clay, then seven feet of clayey graphitic schist. An underlay shaft has been sunk on the seam for possibly 50 feet to water level, in a direction of N. 20° W. on a dip of 37° from the bottom of the shaft. The seam as exposed in the underlay shaft is about five feet thick with no true bottom showing. The roof consists of what appears to be a decomposed micaceous schist, and the graphite seam contains numerous lenticular patches of sandy material and is drag folded in an intense manner, in some instances.

The material in the dumps of the openings on the other seams appears to be similar to that in the top seam—a typical felspathic clayey graphitic schist showing bedding (or schistosity?) with the graphite present as extremely fine amorphous particles presenting a dull appearance in hand specimens.

Water and Mining Timber.

Ample supplies of jarrah and karri are available on the claim and sufficient water for treatment purposes would probably be available from mining operations. A battery of wells sunk in the swampy creek at the south end of the claim and adjacent to the deposits would also provide treatment water.

Estimate of Ore Reserves.

It is impossible in the present state of development of these deposits to make any estimate of ore reserves, and a considerable amount of prospecting will be necessary before the extent of the graphite bearing seams can be determined.

The deposits appear to be of sedimentary origin, and it can be anticipated that they will have some continuity along the strike and down the dip.

Quality of the Graphite.

A representative sample of the top seam was taken and submitted to the Kalgoorlie School of Mines for treatment.

It is understood that the owners of the lease are conducting experimental work on the material in an oil-floatation unit set up in Perth, and that it is their intention to ultimately erect a treatment plant on the claim.

General Remarks.

The deposits as examined on December 1st, 1943, constituted a "good prospect" only, and owing to lack of information about the extent and quality of the graphite-bearing seams, were certainly not in the condition to warrant the erection of a treatment plant.

If a successful treatment process can be evolved to secure an amorphous graphite concentrate of a good carbon content by oil floatation processes, and if the market requires amorphous graphite at a suitable price, then the deposits would be worth prospecting.

REPORT ON A WOLFRAM DEPOSIT ON P.A. 2472, ABOUT SIX MILES N.E. OF MT. GIBSON, YALGOO GOLDFIELD.

Approximate Lat. 29° 32' S.

Approximate Long. 117° 00' E.

By H. A. Ellis, B.Sc., A.O.S.M., Government Geologist.

Locality.

This prospecting area is situated about six miles north-east of Mt. Gibson near the old Bonnie Venture group of gold leases. It is reached by travelling two miles east from the 216 mile peg on the Great Northern Highway, along the Mt. Gibson Station track as far as the old "Harp" Gold Mine, where there is a windmill and tank, and then about 10 miles in a north-north-easterly direction on a winding bush track to some steep hilly country. The ground pegged is on a north-south ridge cut by a west trending deep, dry gully. The inspection was made on October 24, 1951.

Geology.

The country rock is a series of metamorphosed fine and medium grained tuffs of acid composition. They strike N. 20° E., and dip at about 60° to the west. Some of the beds are silicified at the surface, but are much softer underground and weather with a purple tinge. Other beds are hard and fresh on the surface, highly jointed, and will probably continue to be so underground. A series of four quartz reefs varying in width from two inches to two feet and showing a pegmatitic phase in places, have been injected into the steeply dipping meta-sediments along fracture planes having a general strike of N. 70° E. and a dip of from 30° to 60° to the south. These pegmatitic quartz reefs carry disseminated wolfram in association with dark coloured quartz. Occasional concentrations of fine, scaly, rosette shaped lepidolite mica occur at or near the hanging or footwall of the small reefs. No felspar was noticed in the reefs, though exposures were too limited to be able to state that none occurs.

Four wolfram bearing reefs were seen in a distance of about 800 feet, the strongest occurring on the north side of the gully. This reef has been cut by two adit tunnels about 40 feet apart vertically, and driven on for short distances. A winze

some 40 feet deep has been sunk on the reef from the lower adit. The reef varies in width from two inches to two feet, and has soft kaolinised walls. Only occasional specks of wolfram were visible in the quartz, and a grab sample from a dump of about 180 tons of mixed reef and wall rock mined from the upper adit is reported to have assayed .039% WO_3 per ton. A trial parcel of this ore has been carted to the nearest railway siding at Wubin (60 miles) for transport by rail to the Cue State Battery for crushing and concentration in a stamp battery and on a Wilfley table. At the time of writing (Oct.) the return from this crushing is not available.

About 400 feet S. 25° W. from the adit workings several thin quartz veins striking N. 70° E. and dipping from 30° to 60° south have been opened up to a maximum depth of about eight feet on top of the ridge. Their greatest width is about 10 inches and the maximum length over which they had been traced was about 30 feet. The country rock here is a hard silicified, metamorphosed tuff, strongly jointed. Occasional small concentrations of wolfram intergrown with muscovite mica and quartz occur in a matrix of dark coloured quartz, and the predominantly siliceous veins vary rapidly in width both in strike and dip.

It is extremely unlikely that the wolfram content of these "leaders" will pay for their extraction and treatment, involving as it does the mining of up to 30 inches or more of hard footwall rock, the road haulage of 60 miles to rail, and a further rail journey of 333 miles to Cue, and crushing and realisation charges in addition. The present price of wolfram is about £A27 per long ton unit of WO_3 . (Oct. 1951).

Production.

The same ground was held during 1942 and 1943 as prospecting area No. 2325, and the following is the official recorded production during those years:—

Period.	Ore Treated.	Concentrates.	WO_3 Content.	Equivalent Long Ton
	(tons)	(lbs.)	(lbs.)	Units.
1942	0.25	51.00	33.15	1.47
1943	13.25	493.00	325.85	14.53
Total	13.50	544.00	359.00	16.00

This ore was hand picked and selected prior to treatment. No production has been recorded to date (Oct. 1951) from the present holding (P.A. 472).

FINAL PROGRESS REPORT ON A GEOLOGICAL SURVEY OF THE METROPOLITAN AREA.

By J. C. McMath, B.Sc. (Hons. Lond.), F.G.S., M.A.I.M.M., Senior Geologist.

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Introduction.

Economic pressures arising from World War II emphasised the urgent need for a more comprehensive and precise knowledge of the geological

resources of the Metropolitan Area. This survey was initiated in August, 1950, and its terms of reference were purely economic in character.* Two reports upon the southern portion of the Area were made available to interested parties. This southern area, the Armadale Sub-Area, was completed in December, 1950, and the results published in brief in the Annual Progress Report of the Geological Survey for that year. This publication details the objects and modus operandi of the survey. The present report concerns itself with the Bullsbrook and Wanneroo Sub-Areas together with the built up portions of the city of Perth and Fremantle.

Some 800 square miles have been mapped to a scale of 20 chains to the inch, prospected, and sampled in broad outline. Some 215 samples were taken and tested for industrial suitability. Where tests warranted, "follow up" boring with hand equipment was carried out wherever possible.

Definition of the Metropolitan Area.

The maximum area authorised for investigation extended from the latitude of Muchea southwards to that of Safety Bay. The eastern boundary was the longitude of Glen Forrest.

For convenience of operation, determined by demand priorities of materials, communications, and proximity to the city, the Area was divided into sub-areas centred about Armadale, Bullsbrook, and Wanneroo. The Bullsbrook and Wanneroo Sub-Areas (including the built up portions of Perth and Fremantle) form the subject of this report and comprise some 800 square miles.

Reference Maps.

Reference maps to the Metropolitan Area as defined by the Survey are:—

(a) *Lands and Surveys Department Lithos*:—
29/80 – 31/80

341A/40, 341B/40, 341C/40, 341D/40.

(b) *Military Maps*, 1 inch = 1 mile:—

Mundaring	Zone 1	No.
Yanchep	392
Toodyay	393
Perth	398
Fremantle	404
Kelmscott	405
Rockingham	410
Jarrahdale	411

Sample and Location References.

Such references are, for convenience, given in terms of the military grid. This grid will be incorporated with the published geological map.

Publication of Results of the Survey.

The results will be presented concisely in the following form:—

(a) Contoured Geological Map to a scale of 1 inch to the mile—with an economic summary.

(b) Overlays showing distribution of industrial rocks and minerals, sample locations and broad results, and relevant economic notes. Such overlays will be:—

- Clays, loams, shale, kyanite.
- Limestone, lime sands, bog limestone.
- Silica (sands, quartz, diatomite).
- Dimension Stone and Aggregate (other than limestone) including laterite, granitic gneisses, dolerites, etc.
- Water—including drainage lines, ground water wells, artesian bores.
- Land Utilisation.

* Annual Progress Report G.S.W.A., 1950.

Personnel.

Six professional officers (including one temporary) have been engaged upon this survey during the period. They were:—

Geologist.	Function.	Period.
J. C. McMath	In Charge	Aug., 1950-Oct., 1951.
N. M. Gray	Field Duties	Aug., 1950-Oct., 1951.
J. Sofoulis	Field Duties	Aug., 1950-Oct., 1951.
L. E. de la Hunty	Field Duties	Aug., 1950-Apr., 1951.
G. H. Low	Field Duties	Aug., 1950-Oct., 1951.
A. Glance	Field Duties	Aug., 1950-Dec. 1950.

Industrial Rocks and Minerals of the Area.

The principal industrial uses for rocks and minerals which may occur are:—

Clays and Shales—brick, tile, pipe making.

Clays—minor ceramic uses—cement.

Sands—foundry uses, glass, filters, etc.

Diatomaceous earths—filters, insulating shapes, etc.

Gravels—road surfacing, aggregate material.

Limestone—chemical, industrial, and agricultural uses—dimension stone.

Salt—industrial uses.

Refractories other than clays and shales (possible in the Pre-Cambrian rocks).

Igneous and Metamorphic Rocks—dimension stone and aggregate material.

THE BULLSBROOK SUB-AREA.

Location and Communications.

Bullbrook lies 28 miles north of Perth upon the Midland Railway Line and is adjacent to the Northern Highway. Within the Sub-Area gravel roads give access to the Chittering Valley from East Bullbrook and Muchea; to Toodyay from Midland Junction (through which centre passes the Eastern Highway); to Gingin via Muchea.

Access to the Perth-Yanchep road (Wannaru Sub-Area) is poor and is confined to a gravel road from West Swan (the Gnangara road) and a sand track from Bullbrook to the Lake Pinjar road (Neaves Road).

On the Darling Ranges access in some detail may be had by timber tracks, etc., but westward access by track is limited and poor.

Geological Outline.

From east to west the broad geological elements of the Bullbrook Sub-Area are:—

- (a) The Pre-Cambrian rocks of the Darling Range. These include granite-gneisses, epidiorites and two occurrences (Chittering Valley and Bullbrook respectively) of meta-sedimentary rocks which have been regionally folded and metamorphosed. In the Chittering Valley these meta-sediments are kyanitic.

On their western margin (the Darling Scarp) these Pre-Cambrian rocks are flanked (unconformably) by Mesozoic rocks in the Bullbrook-Muchea locality and by the Tertiary to Recent sediments of the coastal plain from Bullbrook southwards to Midland Junction. The Pre-Cambrian Cardup Series were not encountered. Associated with these rocks are residual deposits including laterite.

- (b) Confined to the Bullbrook-Muchea region on the western slopes of the scarp is a foothill piedmont zone consisting of low dipping, well dissected, Mesozoic rocks to-

gether with residual and alluvial fan material. Some of the valley heads in this zone are fringed by boulder beds. In general the Mesozoic rocks (sandstones, shales, grits, conglomerates) tend to be ferruginous and lateritised. Approximately a mile east of East Bullbrook (just off the Chittering Road) a "greensand" horizon has been recorded at a depth of 40 ft. in a well section.

- (c) Southwards of Bullbrook the valleys of the Ellen Brook and Swan with their associated clays, loams, and—in the case of the Ellen Brook—bog limestones form a distinct entity. The Ellen Brook bog limestones are noticeably confined to the west bank of the brook.
- (d) Succeeding both (b) and (c) above to the westwards is a zone of vegetated siliceous sand dunes, depressions in which may be swampy and contain sufficient organic matter to support market gardening. This zone continues westwards into the Wannaru Sub-Area.

Outline of Economic Results.

In general the Sub-Area is not well off—either with respect to quantity or quality—for industrial rocks or minerals.

- (a) Ceramic and Brick Clays—are virtually confined to the Swan Valley where problems of land values and utilisation are increasing. Elsewhere, transported clays are limited in extent and confined to the Ellen Brook—they are of no economic importance. Residual clays occur upon the Pre-Cambrian rocks but have a very limited development and present accessibility problems—as also do the kyanitic meta-sediments which, at some undetermined future time, may prove an economic source of kyanite. As far as seen, kaolinitic clays appear to be absent—none being noted beneath laterites on the Range.

- (b) Foundry Sands—(i) "Natural Sands"—these are largely river loams and results of testing, as in Armadale Sub-Area* emphasise the fact that acceptable "natural" sands have a very limited vertical and horizontal distribution.

In any one locality a deposit varies greatly in a short distance—e.g. the Guildford loams at present in use. Limited quantities of "natural" sands can only, then, be located by very close prospecting of loams mapped during the course of the survey.

(ii) *Synthetic Sands*.—Sources of synthetic sands—a silica sand to which a bonding agent such as bentonite is added to produce a foundry sand to specification—are confined to the vegetated siliceous dunes. These sands offer possibilities, either by themselves or after some beneficiation.

- (c) Limestones—the sole limestones within the Sub-Area consist of the bog limestones associated with the Ellen Brook. They could have a local and limited agricultural use.
- (d) Road Metals and Aggregates—are confined to the Pre-Cambrian rocks (lateritic gravels, granite, "Blue" metal) and the Mesozoic rocks (lateritic gravels). Sand, as builders' sand, occurs against the Darling Scarp at Upper Swan and again in the zone of vegetated siliceous dunes.
- (e) Silica—occurs in economic quantity only in the zone of vegetated sand dunes—there is a small but variable iron content.

* Annual Progress Report G.S.W.A., 1950.

THE WANNERU SUB-AREA.

Communications.

Wanneru lies 15 miles north of Perth on the Perth-Yanchep road (bitumen). Within the Sub-Area eastwards access is confined to Neaves Road (sand-track) previously mentioned and the Gnan-gara—West Swan road. Westwards access, north of Balcatta, to the coast is limited to sand tracks and is not good.

Broad Geological Outline.

The broad geological elements of the Wanneru Sub-Area are from the east to west:—

- (i) A zone of vegetated siliceous dunes (the western-most zone of the Bullsbrook Sub-Area) which are bounded on the west by a series of lakes (both permanent and seasonal) and swamps which trend approximately north-south. This zone achieves its maximum width in the south where it fringes the Swan Valley.
- (ii) A zone of calcareous sandstones (Coastal Limestone) which extends to, and comprises, the coast line. Its western margin is fringed with both live and fixed calcareous sand dunes. The zone achieves its maximum width in the Yanchep locality and tapers southwards. Major areas of cap-rock are largely confined to the terrain north of Wanneru township. A chain of lakes and swamps (permanent and seasonal) trend north-south in the central position of the zone and extend from Yanchep southwards to Perth.

Outline of Economic Results.

The potentialities with regard to industrial rocks and minerals are limited with regard to variety and quality of material and, unless some form of beneficiation is employed, with regard to quantity.

- (a) Foundry Sands—Only "synthetic" sands are available either within the zone of vegetated siliceous dunes (some beneficiation may be possible to give a more even grading) or lake systems (where some grading of material is evident).
- (b) Glass Sands—The evenly graded finer sands of the lake systems offer possibilities—Lake Gnan-gara being a present source of supply.
- (c) Limestone (Chemical and Agricultural)—Industrial demand is for a CaCO_3 content of 80 per cent. or better. This until beneficiation is practised, imposes a very narrow limit upon available quantities which, in any one locality, are of the order suitable to the local lime-burning industry. From the cement manufacturing aspect, the choice would appear to lie with either:—
 - (i) Beneficiation of limestone—in which case commensurate reserves of material 70-80 per cent. CaCO_3 in grade are available.
 - (ii) Accepting a lower grade limestone and using a high alumina clay.

The latter would involve beneficiation of the kaolinitic clays to remove free quartz grains. In either case deep exploration of the coastal limestone is necessary before definite reserves can be located or industrial policy formulated. The belt of limestone between the south end of Lake Pinjar and Yanchep (east of the Yanchep Road) appears to offer the most promising prospects for deep exploration—although equal prospects more restricted as to area are located closer to the coast in the locality of Burns Beach and Quinns Rocks.

- (d) Lime Sands.—Within the quadrangle mentioned above occur lime sand dunes. These dunes, both "fixed" and "live" parallel the coast and occupy a zone which may have a width of up to a mile. They are,

in places, of large dimensions and may show a horizon of secondary enrichment. Some are very high in CaCO_3 content (one averaging 89 per cent. over a depth of 5ft.) and merit quantitative investigation—especially if beneficiation be contemplated. They could show large reserves.

- (e) Diatomaceous Earths—occur in the chains of lakes and swamp throughout the sub-area. The thickness of the deposits ranges from 2in. to about 5ft. All carry varying quantities of organic matter and quartz sand—the latter (until beneficiation is practised) proving a handicap where an otherwise economic quantity of material exists. To date the main use for the material has been in the production of insulating shapes. In general the characters of the diatoms do not favour uses for filtration—research may overcome this point. The chief present sources of diatomaceous material are from the Gnan-gara and Badgerup localities. Apart from these localities, the outlook for economic grade and quantity of diatomaceous earths is not promising until some effectual means of removing quartz sand comes forward and lies within the economic production framework of the material.

- (f) Aggregate Materials, Dimension Stone.—

(i) Aggregate Materials.—Coastal limestone furnishes the only coarse aggregate material for road construction purposes, whilst the fixed siliceous sand dunes together with the better graded lacustrine sands are the only source of indifferent aggregate for building purposes or cement brick and tile manufacture.

(ii) Dimension stone is available in the coastal limestone and has, just north of Perth been extensively produced from small quarries in the past; it does not, however, appear to compare with the No. 1 grade stone (reference Annual Progress Report, 1950) produced in the Spearwood area south of Perth. It could, however, be of fair utility.

Summary.

Fieldwork in the Bullsbrook and Wanneru sub-areas was commenced in January and finished in August, 1951. Some 800 square miles were mapped on a scale of 20 chains to the inch. Resulting from this work were the following points:—

- (i) That clays of economic ceramic or brick making interest were confined to the Swan Valley.
- (ii) That, as in the Armadale sub-area, natural foundry sands were limited in quantity, extremely variable in characteristics within any one locality, and significant reserves were not apparent. Of "synthetic" (i.e., silica) sands good potentialities were seen. Some beneficiation with regard to grade to suit a particular type of foundry work might prove an economic possibility.
- (iii) That chemical lime prospects, both with regard to limestones and lime sands, was in general better than in the Armadale sub-area, but that large reserves of materials of 90 per cent. of CaCO_3 were non-existent, although adequate reserves of 75-80 per cent. grade material are to be had.
- (iv) That, in general, aggregate materials (other than sand and limestone) are severely restricted to the pre-Cambrian terrain.
- (v) That commercially acceptable diatomaceous materials are very limited in extent, quantity and quality.

In general the resources of the two sub-areas are limited and largely fall below existing industrial standards (where such are to be found). The future of these resources or of a particular field of

use is contingent upon industrial research both into beneficiation methods and technologies of application and the economics thereof.

Acknowledgments.

The writer wishes to express the appreciation of the members of this operation for the co-operation that has been received from official and unofficial bodies and individuals too numerous for specific mention.

NOTES ON THE PROGRESS OF THE RAVENSTHORPE (PHILLIPS RIVER G.F.) GEOLOGICAL SURVEY as at 31/12/51.

By J. C. McMath, B.Sc. (Hons. Lond.), F.G.S.,
M.Aust.I.M.M., Senior Geologist.

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GENERAL.

The Area under geological survey comprises some 4,500 square miles of the Phillips River Goldfield (less the lake country to the north-east) centred about the township of Ravensthorpe. Previous regional work of the Geological Survey (circa 1909 by H. Woodward) was limited to a small area lying between Ravensthorpe and Kundip.

The present work has been undertaken in order to—

- (i) further elucidate the hitherto imperfectly understood regional geology and
- (ii) ascertain, if—and as far as—possible, the relationship of ore mineralisation to regional and local geological structures.

Comprising two phases, the field operations are firstly, regional mapping on 80 chains to one inch and 20 chains to one inch (chiefly in the Ravensthorpe, Eyre, Mt. Barren Ranges and Kundip locality); and secondly, mapping of mining groups on a five chain to one inch. Mapping of the following mining groups is scheduled:—Elverdton, Mt. Mahon, Catlin, Kundip, Hatters Hill, together with certain mineralised pegmatites. The Elverdton Group has been completed.

Survey methods employed consist largely of plane table and telescopic alidade for oriented traverses and resections together with compass and chain traverses.

The party consists of the following:—

- J. C. McMath, Senior Geologist, in charge.
- N. M. Gray, Geologist 2nd Class—field duties as laid down.
- J. Sofoulis, Geologist 2nd Class—field duties as laid down.

Previous official literature is scanty, the principal references being:—

- Bull. No. 5 G.S.W.A.—The Phillips River Mining District—T. Blatchford, 1900.
- Bull. No. 35. G.S.W.A.—The Gold and Copper Deposits of the Phillips River Goldfield—H. Woodward, 1909.
- Mines Dept. Report—The Development of the Phillips River Auriferous and Copper Mines—A. Montgomery and M. Maclaren, 1914.

Apart from a small gold mine operating at Kundip, mining in the district is moribund. Precious metal production from this Goldfield to date (1951) has been:—

Alluvial.	Dolled and Specimen.	Ore Treated.	Gold Therefrom.	Silver.
Fine oz.	Fine oz.	Tons. (2,240 lb.)	Fine oz.	Fine oz.
607·11	818·28	130,485·53	103,285·53	16,020·14

Production for the year 1951 being 63.44 fine ounces of gold from 100 tons of ore.

Total Copper Ore production to date is 95,924.47 long tons of value £589,373. Production for the year 1951 being 4.83 long tons of value £138.

No map is published with these notes by reason of the expense being incompatible with field mapping carried out to date.

GEOLOGICAL NOTES.

1. Physiography.

The following major positive topographic elements noted so far, are:—

- (i) The Ravensthorpe Range—sigmoidal in expression with its longer axis lying approximately 20° north of west.
- (ii) The isolated coastal ranges of Mt. Barren and Eyre, showing raised beaches. These ranges trend approximately 10°-20° north of east.
- (iii) North of the latitude of Mt. Short isolated hills, usually of granitic gneiss, rise above the sand-plain.
- (iv) Again about the latitude of Mt. Short a general east-west trending sinuous and embayed “jump-up” line (vernacular) which separates the Old Plateau from the New Plateau.*

The major drainage pattern within the area shows broad valleys with incised meanders. The trend of the major rivers, the Jerdacuttup, Steere, Phillips, West, and Hamersley, is to the south-south-east (the regional trend of the older Pre-Cambrian-Archeozoic structures). Some measure of control appears to be exercised by structures associated with the Mt. Barren-Eyre Range rocks. The rivers are intermittent, consisting for the major part of the year of fresh, brackish or saline pools. These rivers terminate seawards in brackish or salt lakes—the so-called “inlets”—cut off from the sea by substantial and mainly vegetated sand bars of which the Culham Inlet furnishes a typical example. The water of this “inlet” is at a slightly lower level than that of the sea.

In the salina country of the north-east quadrant of the Area the drainage is reminiscent of the Coolgardie and Murchison Goldfields in that, to date, it appears entirely internal.

2. The Rock Types of the Area.

A broad two-fold grouping of the rocks of the Area is possible. This grouping is in no sense final and may well require modification in detail as the work of the Survey progresses. The two major divisions apparent are:—

- (i) Post-folding Rocks—these comprise the coastal limestones, laterites, and the conglomerates, mudstones, and sandstones about the Kundip railway cutting. Thin spreads of a dominantly quartzose conglomerate may occasionally occur south of the latitude of Kundip capping the lower ridges. Included in this post folding group of rocks are the granitic-gneisses, magmatic granites, economic pegmatites, and quartz-dolerite dykes.

* Bulletin No. 95, G.S.W.A.: Physiography of W.A. J. T. Jutson, 1950.

- (b) **Pre-folding Rocks.**—Whilst all have been in varying degree metamorphosed (regional) granitised, and intruded by magmatic granites and post-granite porphyry and quartz-dolerite dykes, a fundamental major structural separation can be effected, viz.:—

- (i) Regionally folded (average trend 20° west of north) and metamorphosed rocks consisting of Basic Lavas, Ultra-basic rocks, jaspilites. These rocks comprise the Ravensthorpe Ranges and show traces of superimposed structural elements trending approximately N. 70° E. In the Ravensthorpe-Bandalup Creek region these elements appear as "cross-folding" of a minor order. Hence these rocks have experienced two periods of folding (cf. the Older Greenstones of the Coolgardie and Yilgarn Goldfields). In general the degree of regional metamorphism is low—but local "highs" may occur.

In detail the Basic Lavas comprise fine to medium grained rocks, vesicular and amygdaloidal types, metabasaltoid types, porphyritic rock lavas, and volcanic agglomerates. Rare and very thin meta-sedimentary horizons (of no marked value) were noted. The Ultra-basic rocks comprise both fine grained massive and schistose actinolitic, anthophyllitic and tremolitic types together with rare residuals of bedded dolomites (Cocanarup). These dolomites, however, are usually much metamorphosed. Wide developments of serpentine, magmatic in some instances, of uncertain origin in others, are associated with the Ultra-basic rocks. Of economic interest are the developments of manganeseiferous talc schists east-south-east of Kundip on the Jerdacuttup River.

The jaspilites of the Ravensthorpe Area dominate the topography but are, individually, of relatively small thickness—the rounded ridges resulting from lamination of jaspilites and schists. The division between Ultra-basic rocks and jaspilites is logical; the mutual relations of these quite arbitrary and entirely lithological; the mutual relations of these sets of rocks being, as far as has been seen, one of conformable transition. There is no evidence to offer upon the relationship between the Basic Lavas and the Ultra-basic rocks. In the field they appear conformable. Structural evidence in the Mt. Short and Kundip localities makes the Basic Lavas the oldest of these pre-folding rocks, followed upwards by Ultra-basic rocks and the jaspilite group.

- (ii) Regionally folded (upon the "Cross-fold" axis of N. 70° E.) and slightly metamorphosed conglomerates, shales, grits, quartzites which comprise the rocks of the Mt. Barren and Eyre Ranges. They find, to date, their most northern expression in the latitude of Kundip. They contain no structural elements of north-south trend and are clearly involved in a single folding episode and hence are younger than the rocks of the Ravensthorpe Range. Whilst, as also have the latter rocks, they have been intruded by granites and granitised in varying degree, their regional metamorphism is lower in degree than that of the Ravensthorpe rocks.

Mutual Relations of the Ravensthorpe Range Rocks and Mt. Barren and Eyre Range Rocks.

These rocks are to be seen clearly in juxtaposition some two miles east-north-east of Kundip. The salient facts brought out to date are:—

- (i) The singly folded rocks of the Mt. Barren Series consist of shales, grits, quartzites, conglomerates, quartz-breccias (tectonic).
- (ii) The above rocks overlie the rocks of the Ravensthorpe Series and strike N. 70° E., dipping southwards at high and varying degrees whilst the Ravensthorpe Series strikes N. 20° W. with dips oscillating about the vertical.
- (iii) The regional metamorphism of the Mt. Barren Series is low compared with that of the underlying Ravensthorpe Series.
- (iv) Drag-folding and fracture cleavage in the Mt. Barren Series indicates overturning of beds to the north and a low easterly plunge to the major structure.
- (v) The northern expression of the junction of the two series takes the form of a sinuous and deeply embayed north facing gentle scarp line. This topographic expression is consistent either with the outcrop of a series dipping flatly southwards or with the line of emergence of a low angle major thrust plane.
- (vi) In topographic depressions in the Mt. Barren Series, especially in the beds of major drainage channels, "windows" exposing the underlying Ravensthorpe Series are seen—e.g., the creek four and a half miles south-west of No Tree Hill.
- (vii) Whilst no north-south structural components are to date found in the rocks of the Mt. Barren Series, "cross folding" is impressed on the Ravensthorpe Series in varying degree.

There exists, then, a major angular discrepancy between the rocks of the Ravensthorpe Range and those of the Mt. Barren Series. Sufficient work has yet to be carried out to demonstrate unequivocally the true nature of this discrepancy—whether it arises from a normal regional angular unconformity rendered locally complex by "cross-fold" "highs" in the Mt. Barren Series, or whether it arises from low angle overthrusting of the Mt. Barren Series from the southward.

The current view of the author, based upon the related facts and close field acquaintance therewith, inclines heavily on the side of overthrusting, with the dips, brecciated quartzite, suspicions of repetition of strata southwards, the relatively low topographic level development of these rocks northwards of Mt. Barren and the Eyre Ranges suggestive of an imbricate zone on the sole of, or in advance of, a major low angle thrust plane which has carried the Mt. Barren Series northwards over the rocks of the Ravensthorpe Ranges which have acted as a foreland. A firm view at this stage of the work is, however, premature.

Structure of the Ravensthorpe Ranges.

Work has sufficiently advanced to delineate the regional structure of the folded rocks of the Ravensthorpe Range in, and west of, the Kundip-Mt. Short region. East thereof is only known in reconnaissance outline.

Briefly, the structure consists of a north plunging anticlinorial of which Mt. Short forms the nose and the main Ravensthorpe Range the eastern limb. At Kundip there is a suspicion (to be confirmed or otherwise) of the nose of a complimentary synclinorial to the east of the Range. The western limb is traceable southwards, to date, to Cocanarup where it disappears in the granitic gneiss (whose structures parallel this major structure in broad outline). The axial zone trends N. 20° E. and

south of Ravensthorpe, has been occupied by granites and granitic gneisses. The western margin of the eastern limb has been largely granitised. "Cross-folding" is discernible in the McMahon-Bandalup Creek area.

Classification and Sequence of Rock Types.

The classification and sequence which follows cannot, at this early stage of the survey, be regarded as either complete or final. As work progresses it will, inevitably, be subject to modification.

	Age.	Series.	Description.	Remarks.
Kainozoic.	Recent	.... ..	Soils	Various types—alluvial and eluvial.
	Tertiary to Recent	.... ..	Alluvium and lacustrine deposits	May be older or younger than the laterites—possibly deposits of both ages occur.
	Tertiary	.... ..	Laterites ; Coastal Limestone ; High level conglomerates	(1) Laterites of W.A. generally accepted as of Tertiary age. (2) Conglomerates show some degree of correlation with Mt. Barren raised beaches—could be Miocene.
		? Kundip Series	Basal conglomerates, sandstones, mudstones Great Unconformity.	Have low initial dips—overlie unconformably both Ravensthorpe and Mt. Barren Series. Have been regarded as Nullagine in age by H. A. Ellis and E. de C. Clarke. Are not metamorphosed or intruded.
Late Proterozoic or Lower Cambrian.	Nullagine	? Kundip Series	lithology above	See above.
			Igneous Contact	
			Quartz dolerite dykes and quartz-porphyrries	Post folding and post granite.
			Igneous Contact	
			Magmatic Granites—economic pegmatites	Period of Au, Cu, Pb, Ag mineralisation together with intrusion of economic pegmatites.
			Igneous Contact	
			Granitic gneisses and allied rocks Period of Earth Movements	Period of granitisation of pre-Folding rocks.
		? Mt. Barren Series	Conglomerates, shales, grits, quartzites	Regionally folded on N. 70°E. axis—time range unknown but could be early Proterozoic or later.
Archeozoic.		Ravensthorpe Series	Great Angular Discrepancy Period of Earth Movement Jaspilites—Ultrabasic Rocks—Basic Lavas	For lithology, see elsewhere in notes. Basic Lavas and Ultra-basic rocks lithologically and metamorphically similar to those of Yilgarn and Coolgardie Older Greenstones. The jaspilites may represent a condensed Whitestone sequence. Folding was on approx. N-S axis. "Mt. Barren Cross folding" impressed in varying degree upon these rocks.

Future Work.

Carrying forward mapping programme.
Working out detail of relations between Mt. Barren and Ravensthorpe Series.
Further structural delineation of the area.
Correlation, if and as possible, or ore mineralisation with regional and local structures.
Completion of the mining group mapping programme.

ACKNOWLEDGMENTS.

The author wishes to acknowledge help gratefully received from official and unofficial organisations and individuals. In particular he would like to record his appreciation of stimulating and cogent discussion by and advice from the Government Geologist.

REPORT ON WATER SUPPLY AT MURESK AGRICULTURAL COLLEGE, MURESK, W.A.

By J. H. LORD, B.Sc., F.G.S.

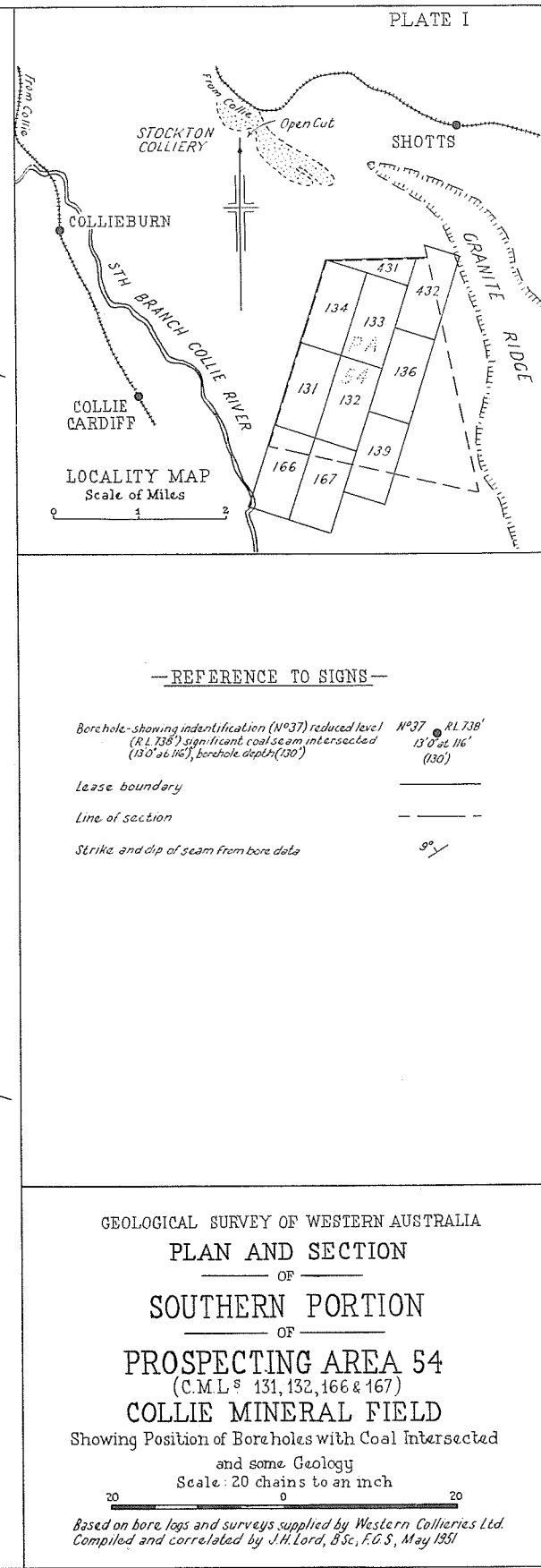
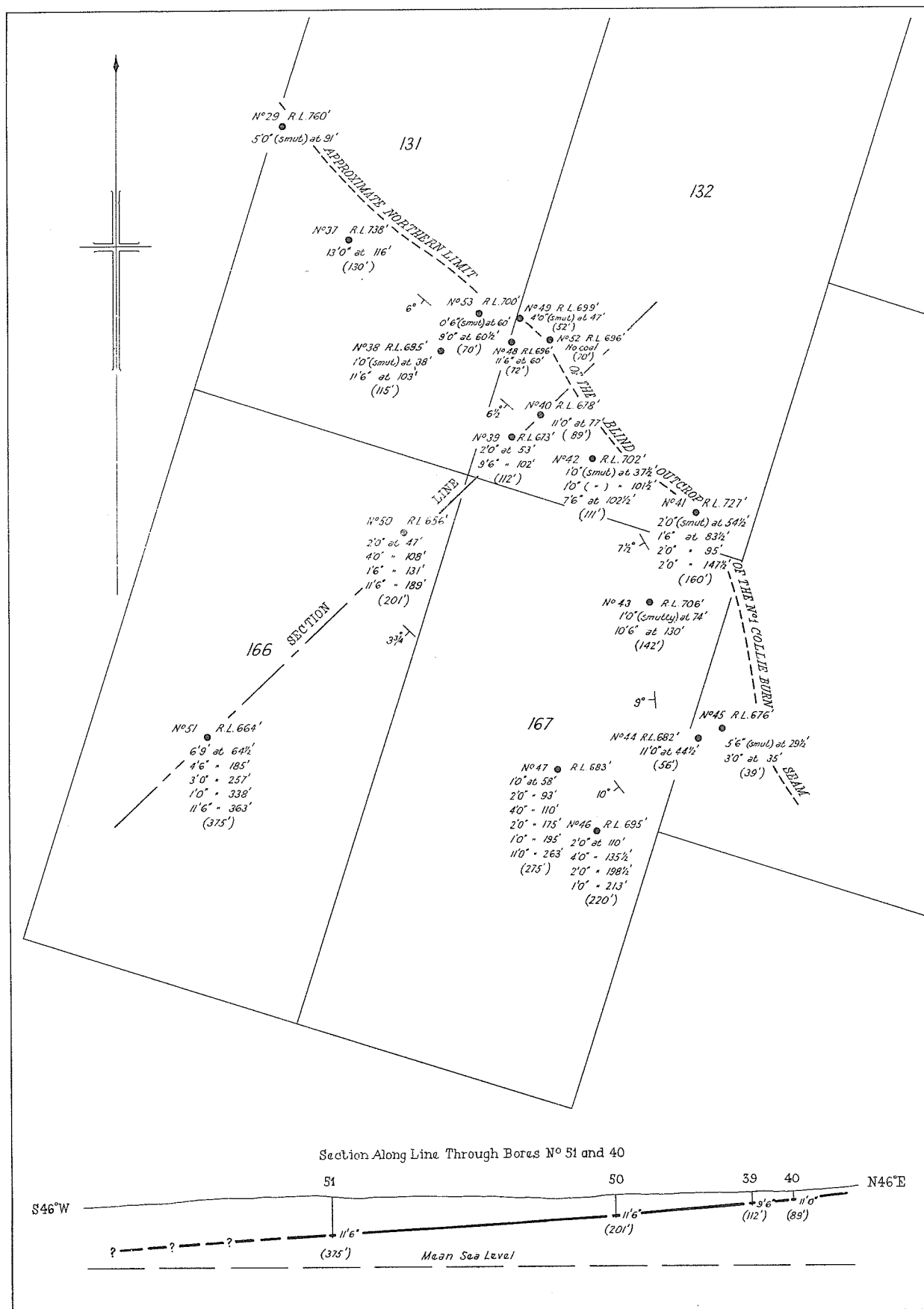
The Agricultural College at Muresk, 50 miles east-north-east of Perth between Spencer's Brook and York, was visited in early January 1951 at the request of the principal to advise on the water supply problem of the College.
As the College buildings are connected to the Goldfields Water Supply pipe line, there is no domestic water supply difficulty. Stock water in

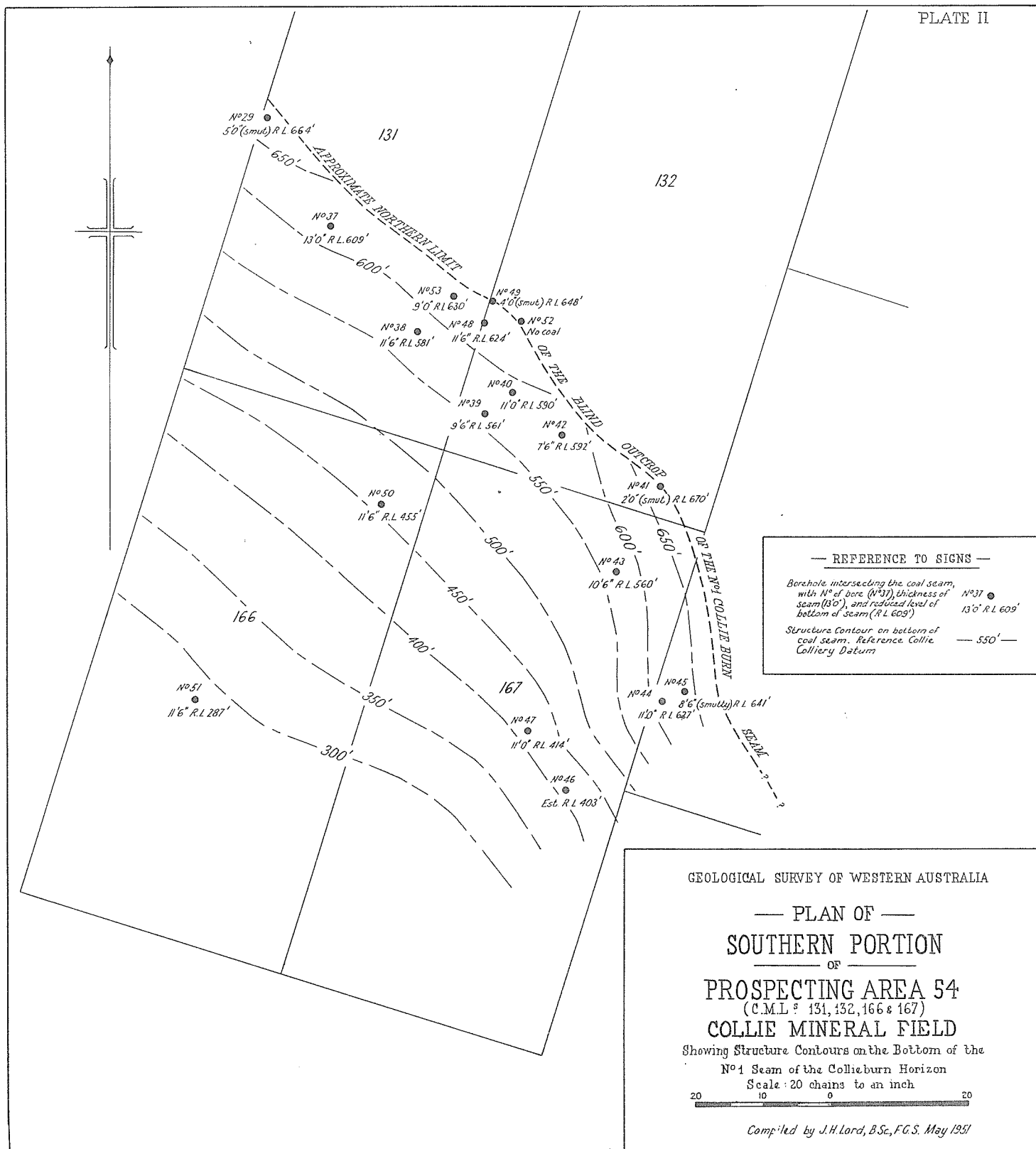
the paddocks has been drawn from numerous soaks, which, due to a number of below average rainfall seasons, have dried out and created the present problem. All the water obtained from the soaks is suitable for stock, while a well at the garden, although slightly brackish now, is suitable for drinking and for the garden. This well, the only one on the property that produces a continuous supply, is 12ft. deep with water at 7ft. below the surface. There is no salinity problem in any of the known underground supplies yet.

A brief general reconnaissance was made of the property, which consists of granite-gneiss with meta-sedimentary rocks and greenstone intrusions. Much of the property is high rocky country dissected by creeks and gullies which, when carrying water, drain in a general south-westerly direction to the Avon River. The soaks occur in and on the slopes of these gullies.

MODE OF OCCURRENCE OF UNDERGROUND WATER.

The following well-known features are most important when searching for water in this type of country, and should be borne in mind when selecting sites for bores.
In order that underground water may exist there must be an effective intake area. If there is a suitable intake area then there must be porous strata (aquifers) to act as a reservoir for the water.





In country such as this with granitic hills and narrow, shallow valleys, the possibility of large underground supplies of underground water is not good. Only in the gullies, where there are patches of sandy alluvium are suitable intake and storage areas likely to exist.

Sites with good prospects of underground water occur immediately upstream from any resistant bar across a gully where suitable alluvium is present. In the brief inspection at Muresk, although resistant bars cross the gullies in places, there did not appear to be any great thickness of alluvium in the gullies.

RECOMMENDATIONS.

There are numerous sites worthy of drilling in the circumstances to ascertain the possibility of obtaining underground water with no guarantee of success but the following sites are suggested, bearing in mind where the greatest need for water exists.

- (1) Top Paddock—in the gully near the northern boundary.
- (2) Clear Hills Paddock—in the gully near the southern boundary.
- (3) Oliver Paddock—where the small gully meets the main creek near the south-west corner.
- (4) Flat No. 1 and No. 2—in either gully, slightly upstream from the soakages.
- (5) Oval Paddock—west of the sand-pit near the fence.

Further sites upstream from Flat No. 1 would be suitable but the soak in Creek Paddock seems quite adequate. Another possibility is, if the Stone Soak Paddock's soak dries out, at the north-west corner of the paddock. Drilling in each hole should be stopped when solid rock (granite, greenstone, etc.) is encountered.

Little can be done to improve the existing soaks except that some cleaning out may improve the supply. Such attention may benefit the soak in Gully Paddock.

It would be of general interest and benefit if some of the underground supplies were tested for salinity at regular intervals. This would eventually show if the waters were becoming more saline and also illustrate any annual variation in salinity.

REPORT ON THE EXPLORATION OF THE SOUTHERN PORTION OF PROSPECTING AREA 54, COLLIE MINERAL FIELD, W.A.

By J. H. Lord, B.Sc., F.G.S.

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GENERAL INFORMATION

This report describes further prospecting for coal on P.A. 54, details of which were enumerated previously in "A Report on a Portion of P.A. 54, Collie Mineral Field, W.A." published in the 1949 Annual Report of the Geological Survey of W.A.

This prospecting, which had been suggested in the report quoted above, was to locate and prove the existence and extent of the top, No. 1 coal seam of the Collie Burn horizon on this area.

There is no previous record of any prospecting on this portion of the P.A., but the seam had been traced up to the western boundary as described in the report "Shallow Drilling for Open Cut Coal on a Portion of Mineral Leases 82, 129 and 130, East Collie Burn, Collie Mineral Field, W.A." by the writer in the 1950 Annual Report of the Geological Survey of W.A.

The drilling, which commenced at the beginning of November, 1950, was done by Kent Bros. for Western Collieries Ltd. under the geological supervision of the writer. The programme described was completed on the 2nd May, 1951.

GEOLOGY AND DRILLING RESULTS.

The general geology of this area has been described in the reports mentioned above.

This drilling programme was planned to trace the blind outcrop of the No. 1 seam of the Collie Burn horizon across the P.A. commencing from the western boundary. An occasional hole was drilled further down the dip to test the continuity in that direction. Of the 18 holes drilled, all except two encountered the seam. Hole No. 46 was not taken deep enough owing to an incorrect reduced level being supplied. The position and details of these holes are shown on Plate I and Table 1.

In following this seam it was found that the blind outcrop varies from a depth of 90 feet on the ridges to approximately 45 feet in the gullies. This actually represents a variation in the thickness of the Pliocene lake deposits, which overlie uncomformably the Permian coal measures.

There is no possibility of a large open-cut along this seam, the only possible areas being in the two main gullies, where the extent would be very small.

As previously anticipated, the strike continues to swing in a clockwise direction across the P.A. varying from N. 50° W. on the western side to N. 3° W. towards the east, but on the far eastern side the strike appears to swing back to N. 38° W.

The dip varies from 6 to 10 degrees in a south-westerly to westerly direction from west to east. The dip of the seam flattens to the south-west and the dip calculated between bores Nos. 47, 50 and 51 is 3½ degrees. The general strike and dip can be seen on the structure contour plan (Plate II). There is no evidence of any serious faulting.

The thickness of the seam away from the weathered blind outcrop varies from 9ft. 6in. to 13ft., with an average thickness of 11ft. 6in. A majority of the bores show the seam to have a soft sandstone roof, which apparently changes to black shale down the dip.

In the hole furthest down the dip, namely bore No. 51, a 6ft. 9in. seam was encountered at a depth of 64 feet. This is the only other seam of economic significance encountered during the drilling. This seam was not investigated further because it would only occupy a small portion of this property.

QUALITY OF THE COAL.

The seam was sampled in all bores, where it was intersected, and a selection analysed by the Western Australian Government Chemical Laboratories.

Although percussion drilling does not provide an entirely satisfactory sample, care was taken to keep the sample as free from foreign matter as possible, and it is considered that a reasonable sample was obtained.

All analyses give fairly consistent results, except the sample from Bore 51 which is the deepest bore. This latter analyses shows an increase in ash content and decrease in calorific value. Occasionally in sampling such as this, one sample may vary greatly from the average, but on the other hand, it may indicate a decrease in the quality of the coal down the dip.

The details of all analyses are shown in Table 2 which gives an average analyses on the 20 per cent. moisture basis of ash 4.4 per cent. and calorific value 9,500 B. Th. U.'s, while the average dry-ash-free calorific value is 12,620 B. Th. U. These values are similar to the values for the seam on the adjoining M.L.'s 82, 129 and 130.

The colour of the ash is pale pinky-grey to fawn, indicating an absence of iron and probably a high ash fusion point.

COAL RESERVES.

As stated earlier there is no suitable locality on this portion of the P.A. investigated for an open-cut. In consequence, the drilling was planned for colliery purposes and the coal reserves have been calculated accordingly. In the following estimates

it is assumed that the seam averages 11ft. 6in. in thickness and that 30 cubic feet of coal is equivalent to one ton.

The portion of the seam enclosed by the blind outcrop and bores Nos. 29, 51, 46 and 45 is classified as Measured Coal and contains 7 million tons. The remainder of the seam to the southern boundary of leases 166, 167 and 139 is classified as Inferred Coal, because it has only been drilled on the northern side; it is reasonable to assume however, that the seam will occur throughout. This portion contains 6 million tons.

			Tons.
Measured Coal	....	....	7,000,000
Inferred Coal	....	....	6,000,000
Total Reserves	....	....	13,000,000

COSTS.

The charge for this drilling was 12s. 6d. per foot. The total drilling cost was £1,475 12s. 6d. which is 0.05 pence per ton for measured coal or 0.03 pence per ton for total coal located.

No allowance is made for administrative and geological expenses.

CONCLUSION.

On this portion of P.A. 54 occurs the No. 1 seam of the Collie Burn horizon, with a prospect of its extending further south-eastwards on to P.A. 57. The seam averages 11½ feet in thickness and the drilling has proven the existence of 7 million tons of measured coal and 6 million tons of inferred coal.

The coal has an average calorific value of 9,500 B. Th. U.'s/lb. with 4.4 per cent ash on a 20 per cent. moisture basis.

This is considered an admirable site for a colliery.

Table 1.

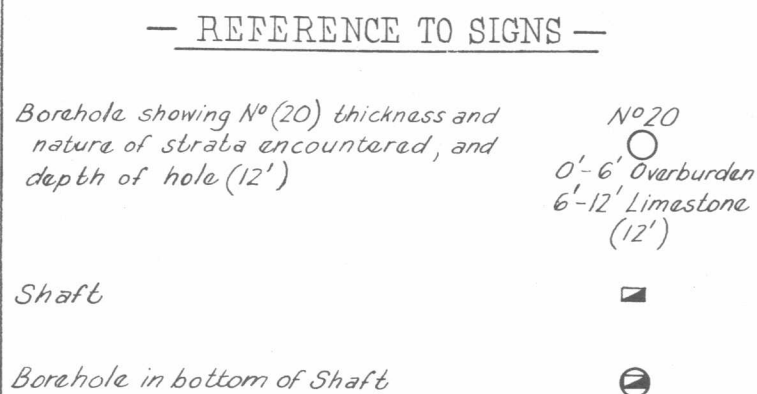
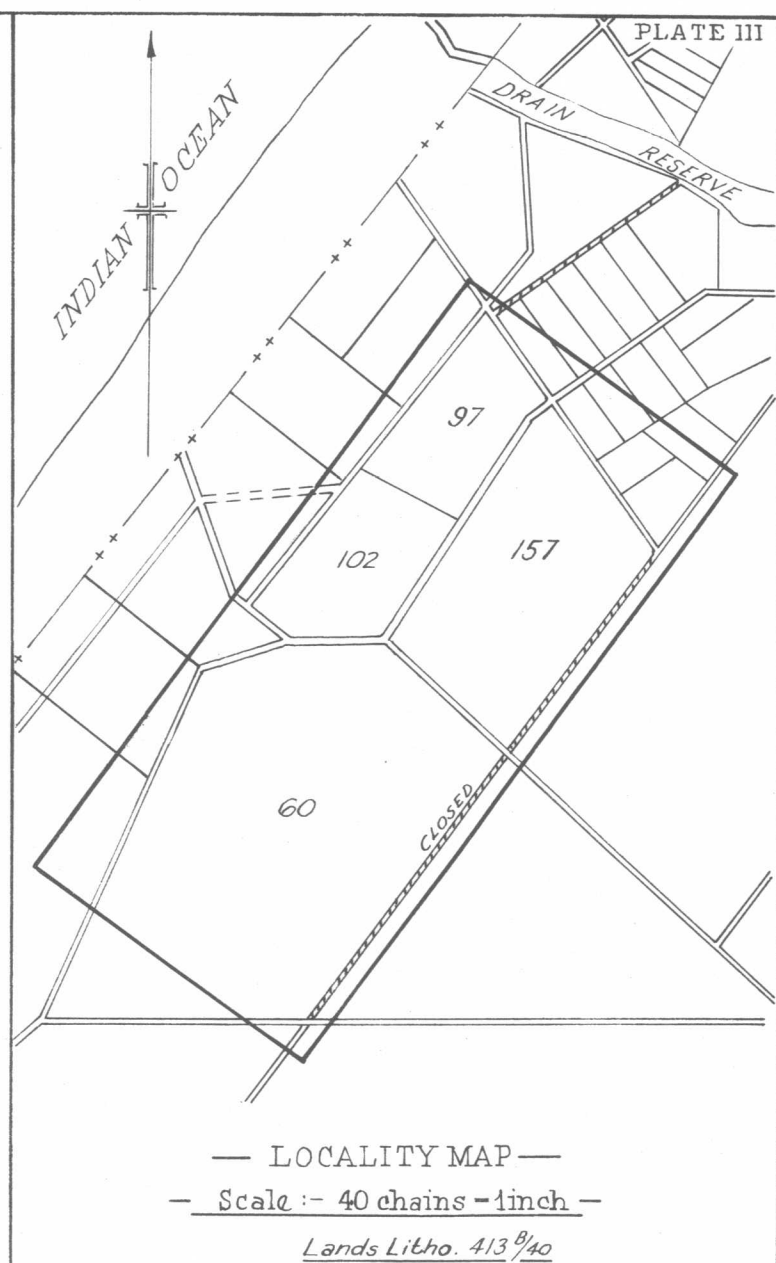
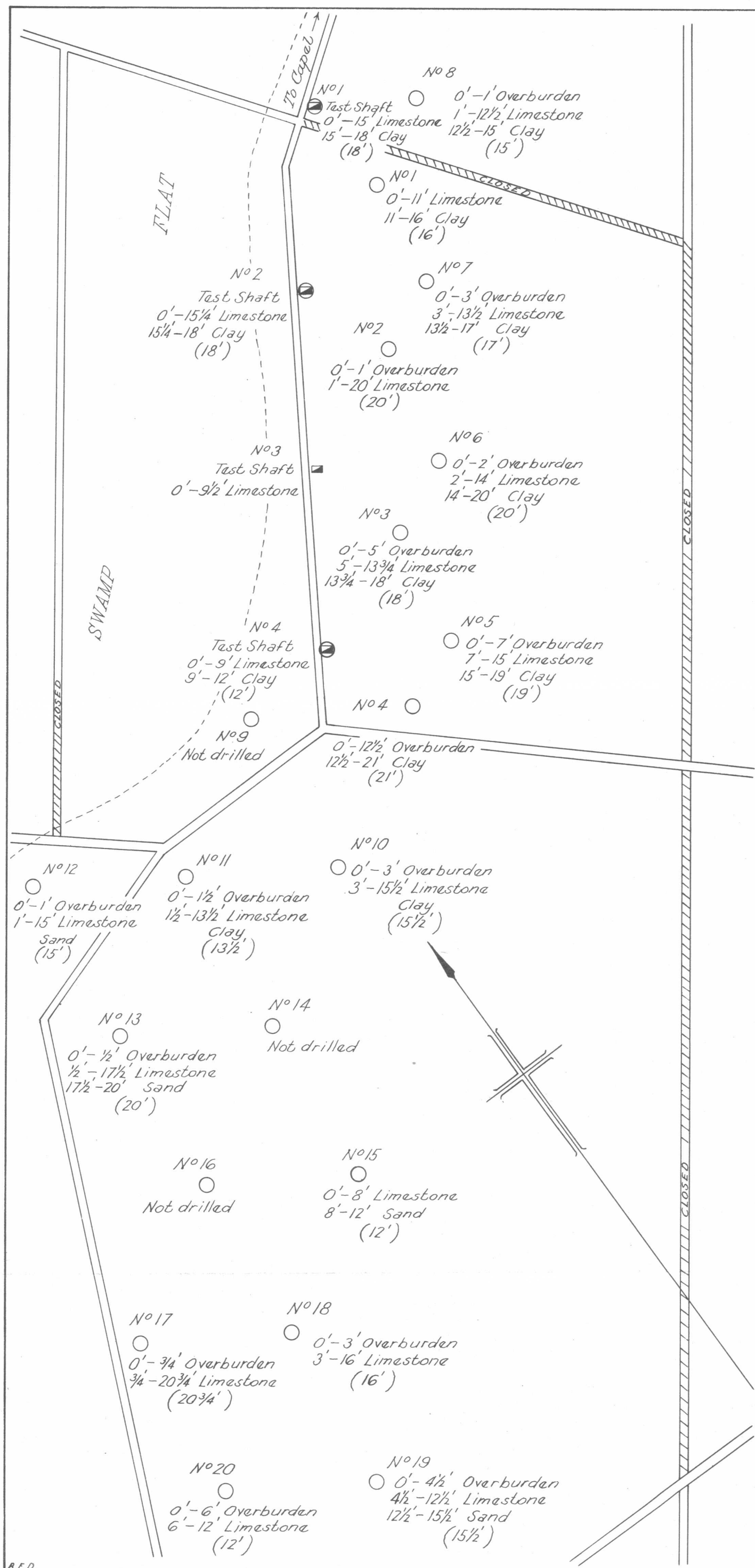
SUMMARY OF BORE LOGS ON SOUTHERN PORTION OF P.A. 54.

Western Collieries Percussion Bore No.	Reduced Level to M.S.L.	Depth of Seam Intersected.	Thickness of Seam.	Depth of Hole.	Depth to Water.	Remarks.
	Feet.	Feet.	Ft. in.	Feet.	Feet.	
37	738	116	13 0	130	No water	
38	695	103	11 6	115	73	
39	673	102	9 6	112	57	
40	678	77	11 0	89	60	
41	727	54½	2 0	160	85	Smut.
42	702	101½	8 6	111	75	Top 1 ft. is smut.
43	677	130	10 6	142	48	
44	682	44½	11 0	56	No water	
45	676	29½	8 6	39	No water	Top 5½ ft. smut.
46	....	....	....	220	80	Hole stopped before reaching seam.
47	688	263	11 0	275	60	
48	696	60	11 6	72	56	
49	699	47	4 0	52	No water	Smut.
50	655	189	11 6	201	42	
51	662	64½	6 9			
		363	11 6	375	52	
52	696	....	....	70	63	No seam. Locating exact outcrop position for mining purposes.
53	700	60	9 6	70	No water	Top 6 in. smut.
54	....	47½	5 6	54	No water	Smut.

Table 2.

ANALYSES OF COAL FROM BORES ON THE SOUTHERN PORTION OF P.A. 54, COLLIE MINERAL FIELD.

Chem. Lab. No.	Bore No.	Depth.	Thick-ness of Sample.	As Received.					Dry and Ash Free.		Ash on Dry Basis.	Colour of Ash.
				Mois-ture.	Ash.	Vol. Matter.	Fixed Carbon.	Calorific Value.	Vol. Matter.	Calorific Value.		
		Feet.	ft. in.	%	%	%	%	B.Th.U.	%	B.Th.U.	%	
10955	37	116	4 6	20.0	3.95	28.00	48.05	9,505	36.80	12,490	4.95	Grey
10956	....	102½	8 6	20.0	3.20	28.30	48.50	9,615	36.85	12,510	4.0	Grey
10957	39	102	4 6	20.0	3.25	28.85	47.90	9,630	37.55	12,540	4.05	Grey
10958	....	106½	5 0	20.0	3.65	28.55	47.80	9,470	37.40	12,410	4.55	Grey
11308	42	102½	7 6	20.0	3.35	29.25	47.40	9,495	38.10	12,380	4.20	Pale pinky grey
11309	43	130	5 0	20.0	4.20	28.70	47.10	9,530	37.85	12,580	5.25	Pale pinky grey
11310	....	135	5 6	20.0	2.60	30.20	47.20	9,735	39.00	12,610	3.20	Pale pinky grey
2288	47	263	5 6	20.0	4.70	29.65	45.65	9,490	39.50	12,600	5.9	Light fawn
2289	....	268½	5 6	20.0	3.75	31.45	44.80	9,610	41.25	12,600	4.7	Light fawn
3686	51	368	6 0	20.0	8.80	27.95	43.25	9,200	39.30	12,930	11.00	Fawn
....	....	372	5 6	20.0	7.40	27.90	44.70	9,155	38.40	12,600	9.20	Fawn
3263	51	64½	6 9	20.00	7.40	29.25	43.35	9,140	40.25	12,580	9.2	Fawn



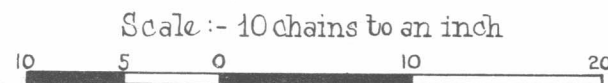
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

— PLAN —
 OF —

PORTION OF STIRLING ESTATE

3 MILES N.W. OF CAPEL
 SOUTH WEST DIVISION

Showing Position and result of Bores Drilled,
 under supervision of Mr. J.D. Gillespie,
 Bunbury Harbour Works.



June 1951

A NOTE ON PROSPECTING AREAS 55 AND 56, COLLIE MINERAL FIELD, W.A.

By J. H. Lord, B.Sc., F.G.S.

In May, 1950, the Griffin Coal Mining Co. Ltd. discussed with the Geological Survey the future of their mining operations. It was obvious, due to faulting and the proximity of the granite that the future of the Wyvern, Griffin and Phoenix Collieries was definitely limited and, as the company did not hold any leases which were likely to contain other seams, it was suggested that a new area be pegged and prospected.

As a result of the Geophysical and Geological Surveys of the Mineral Field and subsequent drilling, it was recommended to the company that the area to the south of Buckingham's and Muja should be prospected, anticipating that the Ewington and Premier horizons of the north-eastern basin would extend in that direction. The company agreed to the recommendation and was assisted in locating P.A.'s. 55 and 56, which were pegged on 18th May, 1950.

A purely exploratory drilling programme was laid out for the southern end of P.A. 56, hoping to locate the Ewington horizon first. When the drilling plant was ready in August, 1950, this portion of the area was inaccessible due to the swampy nature of the terrain. A few holes were drilled on the perimeter of the coal basin without disclosing any coal seams of economic importance. In December, 1950, a move on to the swampy portion of the area was made and two of the first three holes intersected a coal seam, with a thickness of 9 to 10 feet, which is thought to belong to the Ewington horizon. This intersection proves the theory of the north-eastern basin put forward in earlier geological work of this Survey.

The company has continued exploratory drilling without the assistance of the Geological Survey and applied to convert the P.A.'s. into leases in March, 1951.

REPORT ON FURTHER TESTING OF A LIMESTONE DEPOSIT THREE MILES NORTH-WEST OF CAPEL, SOUTH-WEST DIVISION.

By J. H. Lord, B.Sc., F.G.S.

This deposit was reported on previously (Geological Survey of W.A., Annual Report, 1950) as being unsuitable as a flux for the iron industry, due to a high percentage of silica. Later in 1950 the Department of Industrial Development insisted on the deposit being further examined to ascertain if the limestone were suitable for the cement industry.

The Geological Survey set out a grid of proposed bore holes, which were located and drilled by hand drilling methods under the supervision of Mr. J. D. Gillespie, Engineer-in-Charge of Bunbury Harbour Works. The position and results of the bores are shown on Plate III.

The W.A. Government Chemical Laboratories carried out the analytical work.

Sampling Results.

The drillers sampled the limestone encountered, first in two 4ft. sections and then in 2ft. sections, until the floor of the deposit was reached. These samples were all analysed for calcium carbonate and silica and a more detailed analysis made of a composite sample of each hole. Only the composite samples are quoted below because of the poor quality of the limestone. The analytical results of the section samples for each hole are available at the Geological Survey, together with the log of the bores.

The calcium carbonate content is too low and the silica content too high for the deposit to be used as a limestone for cement production as it stands. Any beneficiation process applied to remove the silica would probably increase the magnesium carbonate to a percentage which would be detrimental to the manufacture of cement.

Analyses of Composite Samples from Capel.

Chem. Lab. No.	Locality.	CaCO ₃ .	SiO ₂ .	MgCO ₃ .	Al ₂ O ₃ .*	Fe ₂ O ₃ .
		%	%	%	%	%
1109	Shaft 1 and bore	80.96	12.55	2.48	1.01	0.46
1110	Shaft 2 and bore	72.55	20.49	1.74	1.68	0.95
1111	Shaft 4 and bore	76.42	17.55	1.98	2.18	0.95
1112	Bore 1	77.06	15.75	2.60	1.16	0.52
1113	Bore 2	80.05	9.04	2.66	0.77	0.74
1114	Bore 3	75.86	12.51	3.35	0.98	0.69
1115	Bore 4	72.39	21.27	2.24	1.49	0.63
1116	Bore 5	81.66	13.67	0.79	1.10	0.52
1117	Bore 7	71.08	21.89	1.02	1.95	0.66
1118	Bore 8	70.04	22.34	2.31	1.68	0.42
7952-5	Bore 10	74.64	18.54	n.d.	n.d.	n.d.
7956-9	Bore 11	56.61	36.85	n.d.	n.d.	n.d.
7960-2	Bore 12	59.76	31.77	n.d.	n.d.	n.d.
1119	Bore 13	74.57	19.60	1.55	1.19	0.86
1666	Bore 15	76.50	17.25	1.30	3.26	1.02
1120	Bore 17	70.91	24.33	0.54	1.47	1.10
1478	Bore 18	69.68	25.23	0.86	3.12	0.76
1121	Bore 20	62.56	31.88	0.65	3.24	0.96

* Includes TiO₂ and P₂O₅. n.d. = not determined.

Reserves.

The limestone, where intersected by bores, varied from 9 to 20 feet in thickness, with an approximate average of 13ft. The drilling programme blocked out 3½ million cubic yards of limestone with a soil overburden of 3ft. or less. In addition there are at least half a million cubic yards between the western bores and the swamp. Probably this would have to be left in an endeavour to keep the water out of any proposed quarry which would encounter a water problem due to the low terrain of the deposit.

Conclusion.

Due to the poor quality and the location this deposit is not considered suitable for the cement industry under present conditions.

REPORT ON DIAMOND DRILLING AHEAD OF EXISTING COLLIERIES, COLLIE MINERAL FIELD, W.A.—1. PROPRIETARY COLLIERY.

By J. H. Lord, B.Sc., F.G.S.

At the completion of the No. 3 hole of the deep drilling programme for the Collie Mineral Field,* the contract with Australian Drillers Pty. Ltd. was terminated, and drilling ceased until new contractors, McCallum Bros. and Grill, were engaged in January, 1951.

In the meantime, as a result of agitation by the coal mining companies and the Collie Miners' Union, the Government had directed that the deep-drilling programme should be suspended and drilling carried out ahead of faults affecting the operations in the Proprietary, Wyvern and Stockton Collieries.

This report describes the three holes drilled ahead of the fault in the main tunnel of the Proprietary Colliery (see Fig. 1).

DRILLING PROCEDURE.

The drilling plant and rig used were similar to that described in the previous reports of the deep drilling.

At site No. 1 a 45ft. tower was erected for breaking rods in 30ft. lengths, but at sites Nos. 2 and 3 a 65ft. tower was used so that the rods could be broken in 50ft. lengths.

Bentonite mud was used as the drilling fluid, the water for mixing being pumped from the south branch of the Collie River.

In the No. 1 hole a 5ft. cavity was encountered at a depth of 199ft. All efforts to fill the cavity having failed, in order to restore the circulation it was necessary to case down to 210ft. The rods became jammed in this hole at 855ft. and could not be moved. As much of the equipment as possible was "backed-off" leaving in the hole 295ft. of rods, one 15ft. core barrel, one diamond bit and one reaming shell. The casing was withdrawn.

* 1950, Lord, J. H.: Progress Report on Diamond Drilling, Collie Mineral Field, W.A. (3), Bore No. 3. G.S.W.A. Annual Report, 1950.

The No. 2 hole proceeded satisfactorily to its target, and all equipment was withdrawn.

In the No. 3 hole artesian water was encountered producing varying rates of flow up to 3,000 gallons per hour, with a head of approximately 20ft. This problem was overcome successfully by mixing barytes, with the bentonite mud until the density was high enough to hold back the water. The hole was cased to 220ft. due to the water and soft nature of the strata. When the casing was withdrawn the hole apparently collapsed, stopping the flow of water. The rods were jammed at 860ft. but were freed after pumping down 44 gallons of distillate and allowing it to stand overnight.

There was another problem associated with the drilling besides those mentioned above. The pumps had difficulty in pumping the thick mud, either

because of the depth or because of the cuttings not settling-out properly and causing excessive wear on the pump parts. The inclusion of a shale shaker in the circuit should help overcome this problem.

While drilling was in progress two 12-hour shifts were worked, and the manner in which the shifts (regardless of number of men employed) and man-shifts were distributed over the various operations is set out in Table I. The figures for hole No. 1 are incomplete owing to the considerable time taken by the new contractors in assembling and sorting the equipment. The time used in setting-up and dismantling the plant again shows that this type of plant is not suitable for these comparatively shallow holes.

Table I.
Time Distribution for Drilling Ahead of the Proprietary Colliery.

Operation.	Hole No. 1. (855 feet.)			Hole No. 2. (976 feet.)			Hole No. 3. (1,100 feet.)		
	Shifts.*	Man-Shifts.*	Percentage† of Man-Shifts.	Shifts.	Man-Shifts.	Percentage of Man-Shifts.	Shifts.	Man-Shifts.	Percentage of Man-Shifts.
Drilling	54	118	....	45	98	63	38	76	55
Break-downs, mud-mixing, maintenance, etc.....	15	34	....	10	20	13	10	24	18
Setting-up and dismantling plant	Unrecorded			13	55	24	10	44	21
Fishing for lost tools	16	64	....	Nil	....	....	3	8	6
Total .....	....	....	....	68	173 (232)†	....	61	152 (206)†	....

* All shifts and man-shifts are 12 hours each except for setting up and dismantling.
† All shifts adjusted to 8-hour shifts for percentage purposes.

Table II.
Time Distribution while Drilling, and Core Recovery.

Driller.	Number of Shifts* Drilling.	Total Footage Drilled.	Average Footage per Shift.	Below 100 Feet.		Percentage of Core Recovery for whole Hole.
				Core Recovered (feet).	Percentage Core Recovery.	
Proprietary Hole No. 1.						
McCallum, K.	25	412	16.5	306½	75.5	....
Grill	24	376	15.7	250½	73.5	....
Miscellaneous	5	67	13.4	3½	....	....
Total	54	855	15.8	560½	74.7	68
Proprietary Hole No. 2.						
McCallum, K.	20	366	18.4	245	67.0	....
Grill	24	555	23.2	355	69.5	....
Miscellaneous	1	55	....	....	....	....
Total	45	976	21.7	600	68.5	63
Proprietary Hole No. 3.						
McCallum, K.	17	436	25.6	261	65.2	....
Grill	21	664	31.6	342	57.0	....
Total	38	1,100	29.0	603	60.3	56

* 12-hour shifts.

The best rate of drilling per man-shift (8 hours) overall was in hole No. 3 with 5.3 feet, compared with the best rate of Australian drillers, which was 4.7ft.

Table II is a study of the operations on shifts when drilling took place. In this table the shifts are of 12 hours' duration, but the average rate

of drilling for the three holes was 14.8 feet per 8-hour-shift as compared with 19ft. for the three holes drilled by Australian drillers. This difference may be due to the fatigue produced on the operators by the long 12-hour shift, particularly night shift; also the core-recovery was 10 per cent. higher accounting perhaps for the slower drilling rates.

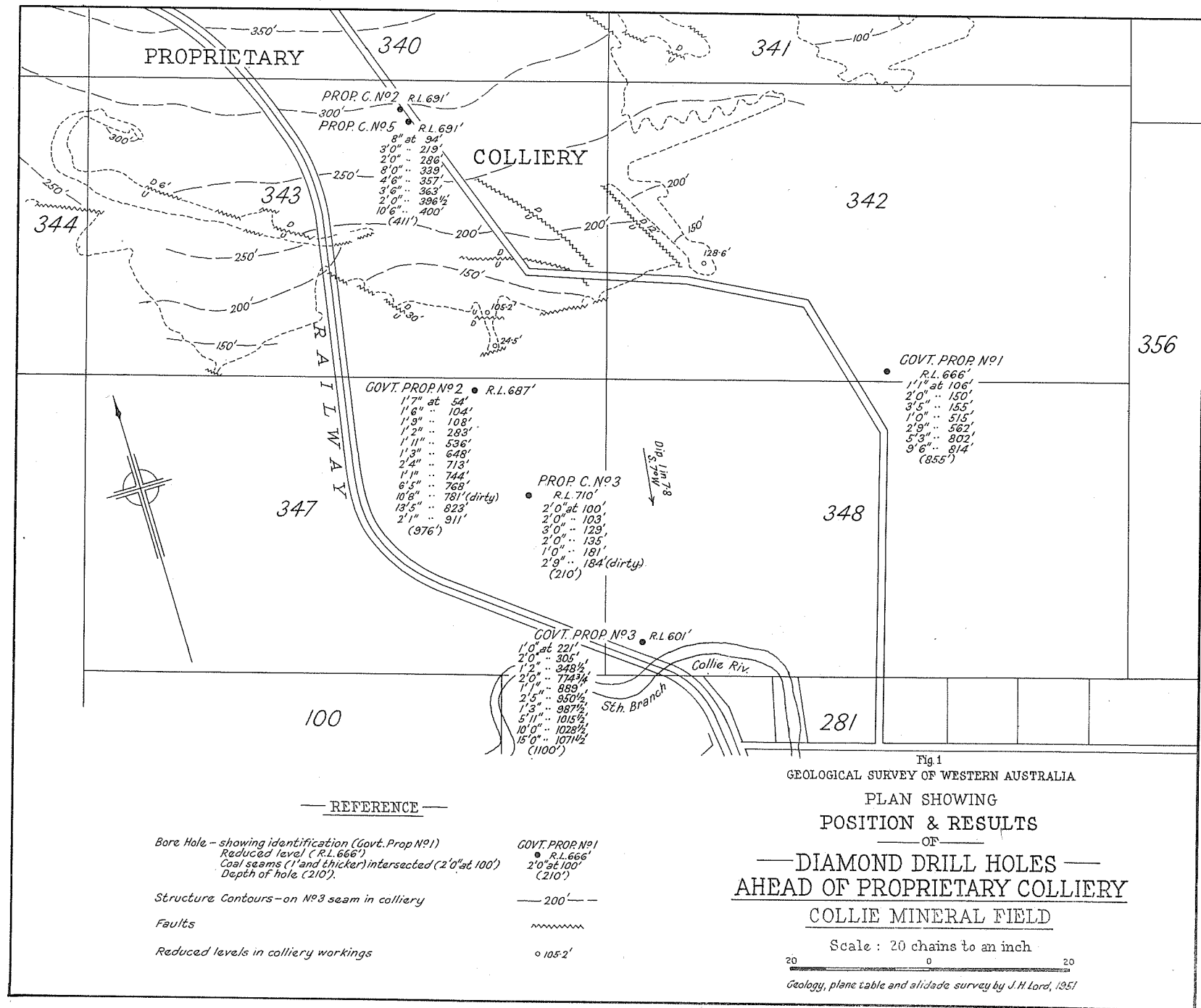


Fig. 2
 PERCENTAGE CORE RECOVERY
 Diamond Drilling Ahead of Proprietary Colliery, Collie, W.A

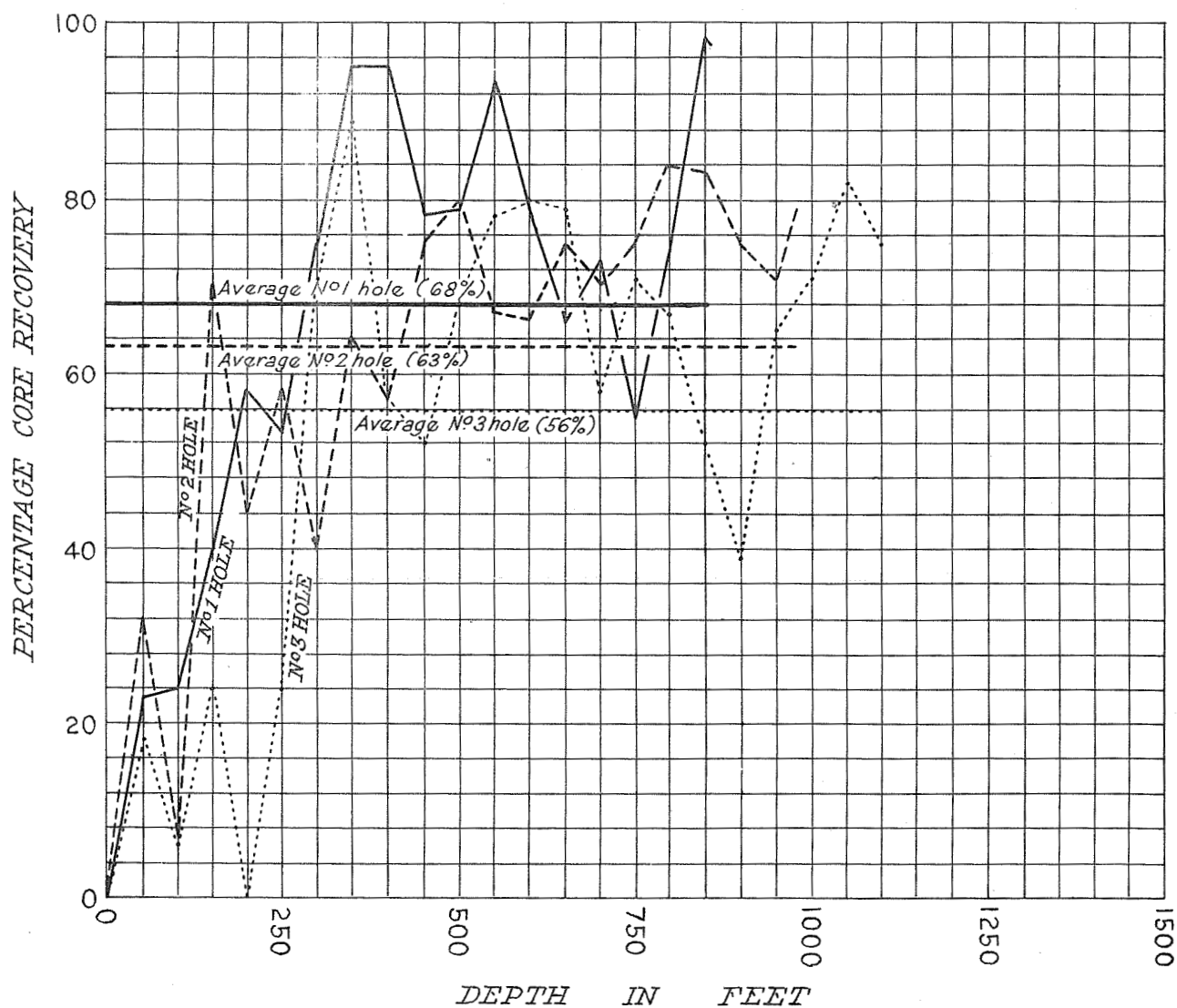


Fig. 3
COLUMNAR SECTIONS
OF
GOVERNMENT DIAMOND DRILL HOLES
AHEAD OF PROPRIETARY COLLIERY
COLLIE MINERAL FIELD

Drillers: McCallum Bros. & Grill
Supervised and logged by J.H. Lord

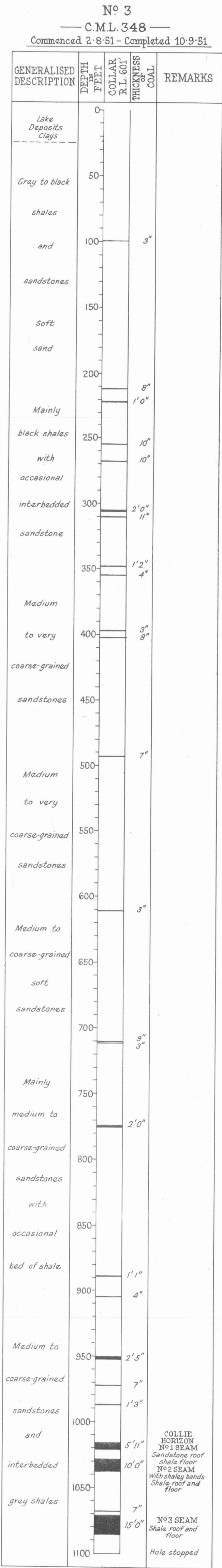
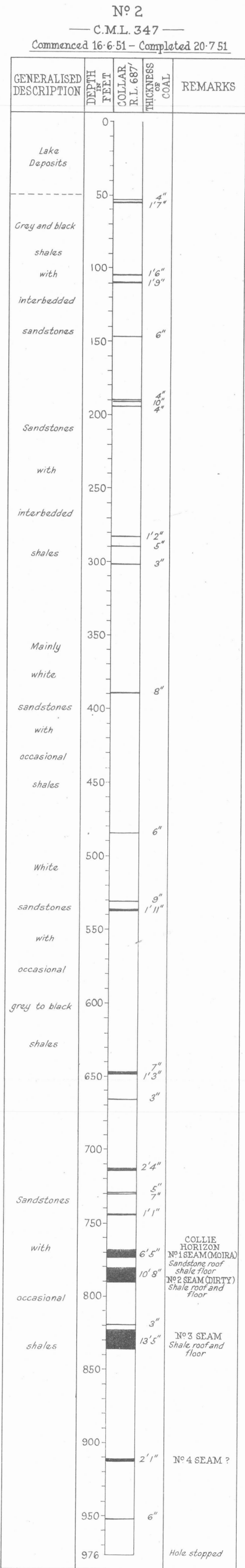
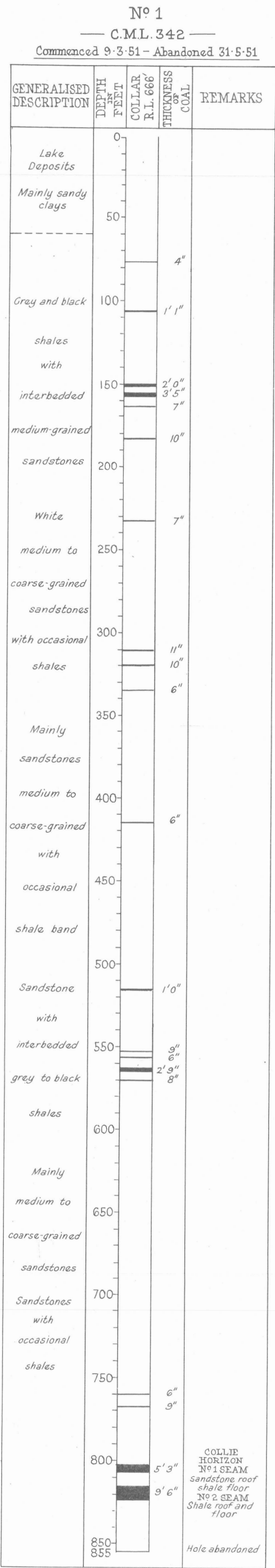


Fig 4

AVERAGE STRATIGRAPHICAL COLUMN OF THE COLLIE HORIZON

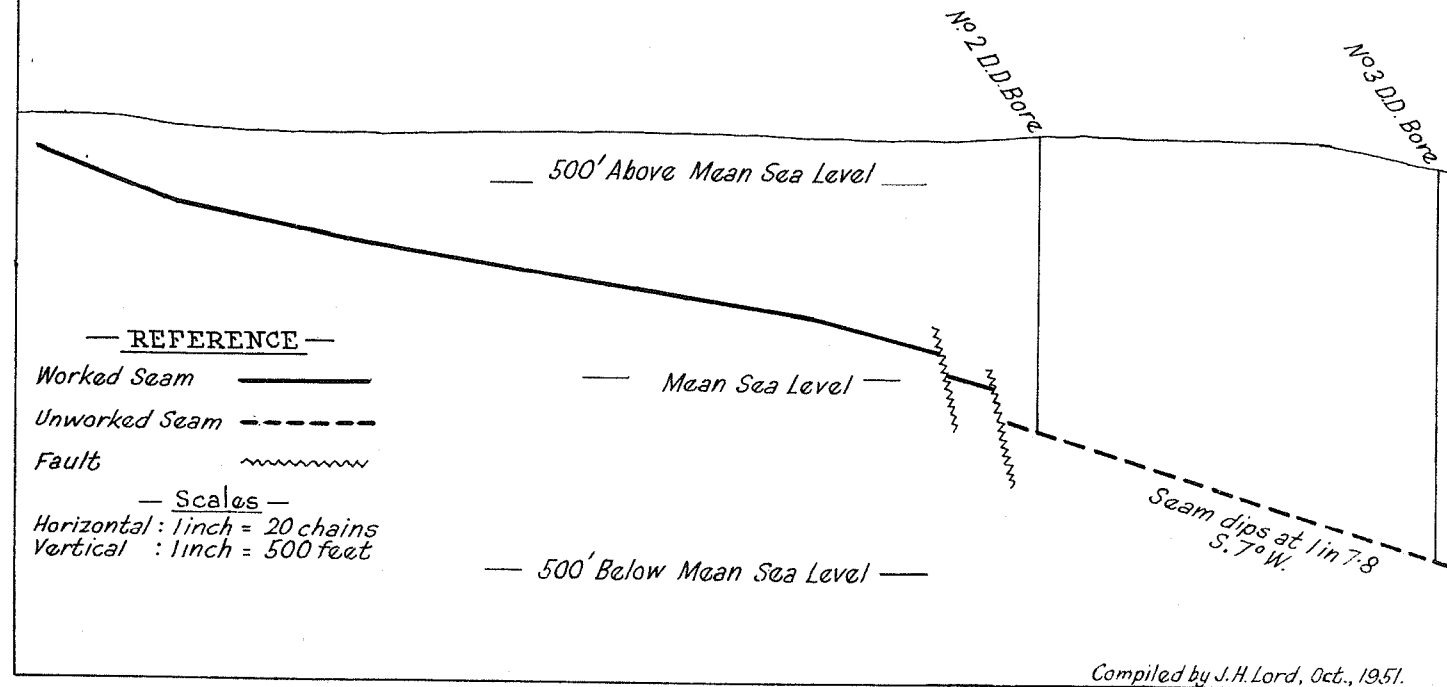
As shown in Bores ahead of Proprietary Colliery

Compiled by J.H. Lord, Oct., 1951

DESCRIPTION OF AVERAGE STRATA	STRATIGRAPHICAL COLUMN Scale: 1 inch = 10 feet	AVERAGE ANALYSIS OF COAL		
		20% MOISTURE BASIS		DRY ASH FREE
		ASH%	CALORIFIC VALUE B.T.U.	CALORIFIC VALUE B.T.U.
Medium to very coarse-grained sandstone with occasional quartz pebbles				
Nº1 SEAM (Moirá) 5' 10" Floor: Black carbonaceous shale		9.9	9,190	13,100
Roof: Black carbonaceous shale				
Nº2 SEAM (Dirty) 10' 1" With occasional thin shaley bands Floor: Black to dark grey carbonaceous shale		16.3	8,200	12,880
Sandstone				
Fine to medium-grained shaley				
Roof: Grey to black carbonaceous shale				
Nº3 SEAM (Wallsend or Proprietary) 14' 3" Floor Black to dark grey carbonaceous shale		10.9	9,270	13,390
Sandstone medium to coarse-grained		8.1	Best 8 feet of Nº3 Seam 9,700	13,500

Fig 5

SECTION ALONG MAIN TUNNEL OF PROPRIETARY COLLIERY
EXTENDED TO GOVERNMENT DIAMOND DRILL BORES
SHOWING BEHAVIOUR OF N°3, OR PROPRIETARY SEAM



CORE RECOVERY AND LOG.

As shown in Table II the core recovery in No. 1, 2 and 3 holes was 68, 63 and 56 per cent, respectively, giving an average of 62 per cent. for the three holes. This compares more than favourably with the 52 per cent. obtained by Australian drillers for three holes.

Fig. 2 shows the core recovery graph for the three holes.

The strata encountered were typical of the Collie Permian coal measures. A summarised log of each hole showing sediments and coal seams (3in. and thicker) is attached as Appendix I. These logs are shown as columnar sections in Fig. 3.

Complete detailed logs of each hole have been prepared and are available at the Geological Survey.

GEOLOGY.

These holes are situated on the downthrow side of the fault at the bottom of the Proprietary main tunnel, which is probably a continuation of the so-called Wallsend Fault. (See Fig. 1.) The coal seams concerned are those of the Collie horizon, and the holes were located with the object of cutting this horizon twice (No. 1 and No. 2 holes) near the fault, but on the downthrow side, and once (No. 3 hole) at a distance down the dip.

The Nos. 1, 2 and 3 seams of this horizon were intersected in all holes, with the exception of hole No. 1, which was lost before reaching the No. 3 seam. Hole No. 2 was continued to 150ft. below the No. 3 seam to investigate the No. 4 seam which exists in places up to 6ft. in thickness. However, here it is only 2ft. thick.

An enlarged columnar section (Fig. 4) has been prepared, showing the average succession through the coal horizon from the three holes. The correlation of the horizon between the holes is particularly good for the usual variable Collie conditions.

The results of these bores show that the seams of this horizon have been displaced approximately 150ft. by two faults at the bottom of the Proprietary main tunnel, as illustrated in Fig. 5. Some years ago a stone drive was extended beyond the fault at the bottom of the main tunnel, and a coal seam was encountered. This was recognised by Mr. H. Sweeney, who was in charge of operations, as the same seam as extracted in the colliery. This showed that the fault displaced the seam from 50 to 60ft. vertically. Further driving down the dip encountered another fault and considerable inflow of water, which caused the project to be abandoned.

According to the drilling results this second fault must displace downwards some 80 to 90ft. vertically.

Assuming that there are no further faults, the seam in the area enclosed by the three bores dips at 1 in 7.8 ($7\frac{1}{2}$ degrees) in the direction of S. 7° W. As this dip is comparable with the dip in the lower workings of the Proprietary Colliery, the assumption that there are no further major faults in this area appears reasonable.

The object of the drilling was not to prove the extent of the coal ahead of the Proprietary Colliery, but its attitude as described above. However, in doing this the horizon has been proved to exist over a triangular area of approximately 115 acres. The No. 3 seam, which is the seam worked in the Proprietary Colliery, contains a total of over two million tons in this area, but due to the quality and existing methods of working it is doubtful if more than one million tons could be extracted.

No doubt the horizon extends a considerable distance along the strike and down the dip from this triangular area.

QUALITY OF THE COAL.

The detailed analyses carried out on samples submitted to the Government Chemical Laboratories are shown on Table III.

Table III.

Proximate Analyses of the Thicker Seams Intersected while Drilling Ahead of the Proprietary Colliery.

Chem. Lab. No. (1951).	Depth.	Thickness of Sample.	Collie Horizon Seam No. and Total Thickness Analysed.	As Received.					Dry and Ash Free.		Ash Dry Basis.	Colour of Ash.
				Moist- ure.	Ash.	Vol. Matter.	Fixed Carbon.	Calorific Value.	Vol. Matter.	Calorific Value.		
Diamond Drill Bore No. 1.												
	Feet.	Ft. in.		%	%	%	%	B.Th.U.	%	B.Th.U.	%	
3262	155	3 5	....	20.00	5.60	28.25	46.15	9,725	37.95	13,070	7.00	Light fawn
5034	562½	2 9	....	20.00	4.80	25.30	49.90	9,940	33.65	13,220	6.00	Pink-brown
7534	802	5 3	No. 1	20.00	8.15	21.35	50.50	9,490	29.70	13,200	10.15	Brown
7535	814½	2 5	No. 2 9 ft. 6 in.	20.00	13.85	21.30	44.85	....	....	....	....	....
7536	817	4 6		20.00	17.55	20.75	41.70	....	....	....	....	....
7537	821½	2 7		20.00	15.10	20.55	44.35	....	....	....	....	....
7535-7537 (Composite)	814½	9 6	No. 2	20.00	15.95	20.90	43.15	8,370	32.65	13,060	19.9	Brown
Diamond Drill Bore No. 2.												
10724	108½	1 9	....	20.0	9.00	25.8	45.2	9,180	36.3	13,280	11.3	Light buff
10725	536	1 11	....	20.0	10.5	22.9	46.6	9,130	33.0	13,040	13.1	Light chocolate
11180	713½	2 4	....	20.0	8.05	22.45	49.5	9,530	31.2	13,250	10.05	Salmon
11181	767½	6 5	No. 1	15.15	12.2	22.4	50.25	9,360	30.85	12,890	14.2	Red-brown
11182	781	5 4	No. 2 9 ft. 6 in.	12.2	22.15	22.0	43.65	7,830	35.5	11,920	25.1	Red-brown
11183	787½	1 5		11.55	29.0	19.7	39.75	7,440	33.15	12,520	32.75	Light red-brown
11184	789	2 9		15.15	10.05	23.30	51.50	9,750	31.15	13,040	11.8	Red-brown
Composite	781	9 6	No. 2	20.0	18.2	....	....	7,680	....	12,400	....	....
11715	823½	2 9	No. 3 12 ft. 3 in.	14.25	25.25	21.90	38.60	7,500	36.2	12,400	29.4	Brown
11716	827½	2 6		15.35	9.55	23.75	51.35	9,880	31.6	13,160	11.3	Dark brown
11903	830	3 8		17.65	7.55	24.20	50.60	10,010	32.4	13,390	9.2	Red-brown
11904	833½	3 4	No. 3	16.2	10.85	23.55	49.40	9,610	32.3	13,180	12.85	Brown
Composite	823½	12 3		20.0	11.9	....	....	9,000	....	13,070	....	....
11717	911	2 1	No. 4	17.85	4.50	25.20	52.45	10,400	32.45	13,400	5.5	Red-brown
Diamond Drill Bore No. 3.												
16776	1,015½	4 8	No. 1	20.00	9.6	20.8	49.6	9,320	29.5	13,230	12.0	Chocolate
16777	1,020½	1 3	5 ft. 11 in.	20.00	11.5	24.0	44.5	9,080	35.0	13,250	14.4	Chocolate
Composite	1,015½	5 11		20.00	10.0	21.45	48.5	9,250	30.6	13,210	....	....
16778	1,028½	3 0	No. 2 10 ft.	20.0	15.4	22.6	42.0	8,470	35.0	13,120	19.3	Chocolate
16779	1,031½	3 0		20.0	15.9	20.6	43.5	8,420	32.2	13,150	19.9	Chocolate
16780	1,034½	4 0		20.0	13.2	20.8	46.0	8,850	31.1	13,230	16.5	Chocolate
Composite	1,028½	10 0	No. 2	20.0	14.7	22.1	43.4	8,620	33.8	13,200	....	....
16781	1,071½	2 3	No. 1 15 ft.	20.0	13.1	19.5	47.5	8,920	29.2	13,320	16.4	Chocolate
16782	1,073½	4 0		20.0	8.1	22.1	49.8	9,800	30.7	13,620	10.1	Chocolate
16783	1,077½	5 0		20.0	8.2	23.3	48.5	9,800	32.4	13,620	10.3	Chocolate
16784	1,082½	1 3	No. 3	20.0	15.8	20.4	43.8	8,690	31.7	13,520	19.7	Chocolate
16785	1,084	2 6		20.0	10.5	22.3	47.2	9,350	32.1	13,440	13.1	Chocolate
Composite	1,071½	15 0	No. 3	20.0	9.95	22.0	48.05	9,480	31.4	13,530	....	....
Composite	1,073½	9 0	No. 3	20.0	8.15	22.75	49.1	9,780	31.65	13,620	....	....

The No. 1 seam, which averages 5 feet 10 inches in thickness, was analysed in each case as one sample. The average of the analyses for the three holes gives a calorific value of 9,190 B.Th.U.'s with 9.9 per cent. ash on a 20 per cent. moisture basis.

The No. 2 seam was sampled in sections because of the numerous bands of low grade coal and black shale. This seam, known usually as the "dirty seam," contains too much ash to be of economic importance. The average calorific value for this seam (10ft. lin.) in the three holes is 8,200 B.Th.U.'s with 16.3 per cent. ash on a 20 per cent. moisture basis.

The No. 3 seam is the best seam, and the average analysis for the complete seam (14ft. 3in.) in the three holes gives a calorific value of 9,270 B.Th.U.'s with 10.9 per cent. ash based on 20 per cent. moisture content. However the best 8 feet of the seam has a calorific value of 9,700 B.Th.U.'s with 8.1 per cent. ash on a 20 per cent. moisture basis.

The Chemical Laboratories have carried out Carbonisation and Washing Tests on all the samples, full details of which are on the Geological Survey File 22/51. The following is the Carbonisation Assay of the complete No. 3 seam as encountered in hole No. 3:—

Carbonisation Assay

	Per 100 gm.	Per ton.
Solid Residue	63.5 gm.	12.7 cwt.
Liquor—100°C	20.0 gm.	44.8 gals.
100°C	4.9 gm.	11.0 gals.
Tar	3.5 gm.	7.8 gals.
Gas	7,520 ml.	2,695 c. ft.
	13.1 Therms per ton.	

Analysis.

	%	
CO ₂	33.2	
O ₂	0.0	
CnHm	2.1	
H ₂	21.1	
CO	13.4	
C ₂ H ₆	5.1	
CH ₄	23.4	
N ₂	1.6	
C.V.	4640 K. Cal/M ₃	486 B.T.U./c. ft.

CONCLUSION.

The drilling ahead of the Proprietary Colliery shows that the Collie horizon of coal seams has been displaced some 150 feet by two faults at the bottom of the present workings. The area examined appears to be unaffected by major faulting.

The quality and attitude of the seams is similar to that in the lower workings of the colliery.

The No. 3 seam is the best seam, averaging 14 feet 3 inches in thickness with a calorific value of 9,270 B.Th.U.'s on a 20 per cent. moisture basis. This seam would provide 8 feet of coal with a calorific value of 9,700 B.Th.U.'s and 8.1 per cent. ash on a 20 per cent. moisture basis, if the mining engineers consider it practicable to work this area.

GOVERNMENT DRILLING AHEAD OF COLLIERIES.

Hole: Proprietary No. 1. M.L. 342.

Depth (feet) Summarised Log.

0 - 60	Lake deposits.
60 - 77	Sediments.
77 - 77½	COAL (4in.).
77½ - 105¾	Sediments.
105¾ - 106¾	COAL (1ft. 1in.).
106¾ - 150½	Sediments.
150½ - 152½	COAL (2ft. 0in.).
152½ - 155	Sediments.
155 - 158½	COAL (3ft. 5in.).
158½ - 162½	Sediments.
162½ - 163	COAL (7in.).
163 - 182	Sediments.
182 - 183	COAL (10in.).
183 - 232½	Sediments.
232½ - 232¾	COAL (7in.).
232¾ - 310	Sediments.
310 - 311	COAL (11in.).
311 - 319½	Sediments.
319½ - 320½	COAL (10in.).

Depth (feet)	Summarised Log.
320½ - 334½	Sediments.
334½ - 335	COAL (6in.).
335 - 415	Sediments.
415 - 415½	COAL (6in.).
415½ - 515	Sediments.
515 - 516	COAL (poor quality 12in.).
516 - 553	Sediments.
553 - 553¾	COAL (9in.).
553¾ - 556½	Sediments.
556½ - 557	COAL (6in.).
557 - 562½	Sediments.
562½ - 565	COAL (2ft. 9in.).
565 - 570	Sediments.
570 - 570¾	COAL (8in.).
570¾ - 760½	Sediments.
760½ - 761	COAL (6in.).
761 - 768	Sediments.
768 - 768¾	COAL (9in.).
768¾ - 802	Sediments.
802 - 807½	COAL (5ft. 3in.).
807½ - 814½	Sediments.
814½ - 824	COAL (9ft. 6in.).
824 - 855	Sediments.

GOVERNMENT DRILLING AHEAD OF COLLIERIES.

Hole: Proprietary No. 2. M.L. 347.

Depth (feet)	Summarised Log.
0 - 50	Lake Deposits.
50 - 53¾	Sediments.
53¾ - 54	COAL (4in.).
54 - 54½	Sediments.
54½ - 56	COAL (1ft. 7in. poor quality).
56 - 104½	Sediments.
104½ - 106	COAL (1ft. 6in. poor quality).
106 - 108½	Sediments.
108½ - 110	COAL (1ft. 9in.).
110 - 146½	Sediments.
146½ - 147	COAL (6in.).
147 - 189¾	Sediments.
189¾ - 190	COAL (4in.).
190 - 190½	Sediments.
190½ - 191½	COAL (10in.).
191½ - 194	Sediments.
194 - 194½	COAL (4in.).
194½ - 283½	Sediments.
283½ - 284¾	COAL (1ft. 2in. poor quality).
284¾ - 289½	Sediments.
289½ - 290	COAL (5in.).
290 - 303	Sediments.
303 - 303½	COAL (3in.).
303½ - 389¾	Sediments.
389¾ - 390	COAL (8in.).
390 - 485½	Sediments.
485½ - 486	COAL (6in.).
486 - 531½	Sediments.
531½ - 532	COAL (9in.).
532 - 536	Sediments.
536 - 538	COAL (1ft. 11in.).
538 - 647½	Sediments.
647½ - 648	COAL (7in.).
648 - 649½	COAL (1ft. 3in.).
649½ - 667	Sediments.
667 - 667½	COAL (3in.).
667½ - 713	Sediments.
713 - 715½	COAL (2ft. 4in.).
715½ - 729	Sediments.
729 - 729½	COAL (5in.).
729½ - 730	Sediments.
730 - 730½	COAL (7in.).
730½ - 744	Sediments.
744 - 745	COAL (1ft. 1in.).
745 - 767¾	Sediments.
767¾ - 774½	COAL (6ft. 5in.).
774½ - 781	Sediments.
781 - 791¾	COAL (10ft. 8in.-poor quality with shale bands).
791¾ - 819¾	Sediments.
819¾ - 820	COAL (3in.).
820 - 823½	Sediments.
823½ - 837	COAL (13ft. 5in.).
837 - 911	Sediments.
911 - 913	COAL (2ft. 1in.).
913 - 952½	Sediments.
952½ - 953	COAL (6in.).
953 - 976	Sediments.

Hole stopped at 976 feet on 20th July, 1951.

Hole: Proprietary No. 3. M.L. 347.
Depth (feet) Summarised Log.

0 - 25 (approx.)	Lake deposits.
25 - 99	Sediments.
99 - 99½	COAL (3in.).
99½ - 211½	Sediments.
211½ - 212½	COAL (8in.-poor quality).
212½ - 221	Sediments.
221 - 222	COAL (12in.).
222 - 255	Sediments.
255 - 255½	COAL (10in.).
255½ - 268	Sediments.
268 - 268½	COAL (10in.).
268½ - 305	Sediments.
305 - 307	COAL (2ft. 0in.).
307 - 310	Sediments.
310 - 311	COAL (11in.-poor quality).
311 - 348½	Sediments.
348½ - 349½	COAL (1ft. 2in.).
349½ - 355	Sediments.
355 - 355½	COAL (4in.).
355½ - 397	Sediments.
397 - 397½	COAL (3in.).
397½ - 402	Sediments.
402 - 402½	COAL (8in.).
402½ - 493½	Sediments.
493½ - 494	COAL (7in.).
494 - 611	Sediments.
611 - 611½	COAL (3in.-poor quality).
611½ - 710½	Sediments.
710½ - 711½	COAL (9in.-poor quality).
711½ - 712½	Sediments.
712½ - 712½	COAL (3in.).
712½ - 774½	Sediments.
774½ - 776½	COAL (2ft. 0in.).
776½ - 889	Sediments.
889 - 890	COAL (1ft. 1in.).
890 - 905	Sediments.
905 - 905½	COAL (4in.).
905½ - 950½	Sediments.
950½ - 953	COAL (2ft. 5in.).
953 - 972½	Sediments.
972½ - 973½	COAL (7in.).
973½ - 987½	Sediments.
987½ - 988½	COAL (1ft. 3in.).
988½ - 1015½	Sediments.
1015½ - 1021½	COAL (5ft. 11in.-No. 1 Seam).
1021½ - 1028½	Sediments.
1028½ - 1038½	COAL (10ft. 0in.-No. 2 Seam).
1038½ - 1068½	Sediments.
1068½ - 1069	COAL (7in.-poor quality).
1069 - 1071½	Sediments.
1071½ - 1086½	COAL (15ft. 0in.-No. 3 Seam).
1086½ - 1100	Sediments.

Hole stopped at 1100 feet 10th September, 1951.

REPORT ON WITTENOOM TOWN WATER
SUPPLY.

(Long. 118°22' E., Lat. 22°15' S.)

By K. Berliat, D.Sc., M.I.Min.E. (Eng.).

Introduction.

The present population of Wittenoom Town is about 500 and a water supply has been provided for 1,000 people. It is understood, however, that Australian Blue Asbestos Limited are planning to step up their production about two and a half times, and a population of 2,500 to 3,000 will possibly be reached. A very much augmented water supply will therefore be required in future, and the services of the Geological Survey were requested to locate a suitable place or places to undertake boring. Accordingly the writer examined the area from the 29th to 31st March, 1951. He was accompanied by Mr. Hamilton, Engineer for Public Works, North-West Division.

Geology and Topography in Outline.

Wittenoom Town is situated on the alluvial flat of the Fortescue River, close to the northern edge of the Hamersley Ranges. These ranges, which form a highly dissected plateau of about 2,000ft. above sea level, consist principally of ferruginous quartzites, quartzites, and shales, with interbedded horizons of dolomite, sandstone, and conglomerate. The complex is sub-horizontal with minor local folding, and forms part of the Upper Nullagine Series.

Wittenoom Gorge runs roughly in a south-west-north-easterly direction, cutting the general strike of the country at right angles, and opening up into the valley of the Fortescue River at about a mile and a half to the south of Wittenoom Town. The gorge is bounded by steep-sided or vertical cliffs of highly jointed and fissured Nullagine sediments. On its lower course there are short laterals, such as Western Gorge, joining the main creek in deep gorges.

Present Water Supply.

The present water supply is obtained from a pool, six miles south-south-west of Wittenoom Town. The pool, which is fed by springs, lies in Western Gorge, about half a mile above its junction with Wittenoom Gorge. The water is of excellent quality and the present daily supply is about 30,000 gallons. It will be possible, however, to increase the supply from this pool to about 67,000 gallons per day as soon as the new pipe line, now under construction, will be in use.

POSSIBILITIES FOR ADDITIONAL SUPPLIES.

Surface Water.—A traverse was made up Wittenoom Gorge and the writer was surprised at the numerous pools of surface water all along Joffre Creek. On the lower portion of the channel, i.e., from about three miles south-south-west of the present mine workings to the mouth of the gorge, the pools are as a rule of smaller size and do not exceed 10ft. in depth, while on the upper portion deep, permanent pools occur about every half a mile or so. It is estimated that a minimum supply of 200,000 gallons per days could be obtained from these higher pools. This, in addition to the present supply, would be sufficient for a population of 3,000.

The distance from Joffre Falls to Wittenoom Town is about 17 miles. The cost of a pipe line for such a distance over rough country would inevitably be high.

Underground Water.—In the writer's opinion, the most favourable bore sites are on the lowermost portion of Wittenoom Gorge, and a site has been selected right on the bank of Joffre Creek, about two and a half miles south-south-west of Wittenoom Town. The site is on alluvium, underlain by jointed quartzites and sandstones of the Nullagine Series. The water from the bore will have to be pumped over a distance of one and a half miles to the main tank.

If the supply obtained in this bore-hole is only a moderate one it is advisable to sink another bore right in the bed of the creek, about 500 yards further down and diagonally across the trend of the channel. In the very improbable case that the water in the first bore should be saline, a site half a mile higher up in the channel should be tested.

It has been pointed out to the writer that in all these cases the danger of loss of equipment through flood waters could easily be overcome.

It is not recommended to drill in the alluvium of the Fortescue River near Wittenoom Town, as the water is likely to be saline. In case the large Fortescue alluvial flats should be tested for potable water, bore sites should be located very close to the channel, in order to intercept the actual underflow of the river.

REPORT ON UNDERGROUND WATER
SUPPLIES—SOUTH AND SOUTH-EAST
STIRLINGS—MT. MANYPEAK—NORTH
FRANKLAND—SOUTH-WEST DIVISION.

By K. Berliat, D.Sc., M.I.Min.E. (Eng.).

Introduction.

South and South-East Stirlings, Mt. Manypeak, and North Frankland are the names given to three large properties, totalling nearly 600,000 acres, which have been purchased by the War Service Land Settlement Board and will step by step be subdivided into individual farms of approximately 1,000 or 2,000 acres.

Most of the area concerned lies in the saline ground water zone of Western Australia and the provision of an adequate water supply, both for domestic and stock purposes, is therefore a major

problem. Apart from Mt. Manypeak the whole of the country under consideration is underlain at a shallow depth by gneissic granite, and although the annual rainfall is relatively high (in the vicinity of 30 inches), the search for useful underground supplies must be governed by the basic principles that apply generally to the conditions in the wheat belt of Western Australia.

These basic principles may be summarised as follows:—

1. Look for suitable catchment areas in decomposed granite along the crest of ridges and on hilltops.
2. Choose sites on the slopes where there is a concentration of the run-off and pervious soil.
3. Keep away from the main valleys and the lowest parts of the district, as the water beneath these localities will be saline.

The examination was carried out from the 10th to 13th April, 1951, and the writer had the advantage of the company of Mr. Fitzsimmons, of the War Service Land Settlement, for the whole of the traverses.

SOUTH AND SOUTH-EAST STIRLINGS PROJECT.

This area, comprising 350,000 acres, is situated to the south and south-east of the Stirling Range, and is bounded by the Kalgan River and the Pallinup River to the south-west and north-east respectively. For immediate purposes only a small portion on the western edge of the property had to be examined. This portion lies on both sides of the road from Albany to Borden, and its centre is situated in approximately Latitude $34^{\circ} 30' S.$ and approximately Longitude $118^{\circ} 00' E.$ Topographically the country forms part of the broad, flat, sandy plain between the Stirling Range and the Porongorup Range. The average height above sea level is about 900ft.

Not less than 15 bores have been put down in order to test the underground water conditions of the area. In all, except one case, these bores struck heavy salt water which, in most cases is useless even for stock purposes. It may be noted that the sites of these unsuccessful bores are in low-lying portions of the sandplain or in shallow depressions, and it is quite obvious that any further drilling in this type of country is only a waste of time and money.

In the writer's opinion geological conditions necessary to provide underground water of useful quality do not exist in most parts of the area under consideration, and the solution of the water supply problem will depend on sources other than those of subterranean nature.

Only one area is suggested by the writer as worthy of trial. About a mile and three-quarters to the north of the War Service Land Settlement Depot the country is gradually rising, and there is a range of flat topped, and not very heavily timbered hills forming a good catchment. This high ground should be tested and a first site has been selected in accordance with the basic principles mentioned above. Other bores in similar positions may be sunk later on, farther to the westward, along the dissected crest of the ridge.

It may be noted in passing that the only successful bore drilled so far lies in this area.

MT. MANYPEAK PROJECT.

The centre of the 40,000-acre Mt. Manypeak project is situated in approximately Latitude $34^{\circ} 50' S.$ and Longitude $118^{\circ} 10' E.$ With the exception of a small portion in the south-east corner the whole of the property is underlain by the Miocene Plantagenet Beds. These beds, consisting mainly of pervious sandstones, are highly absorbent and form an ideal formation for the storage of underground water. This fact, together with the relatively high annual rainfall of 30 to 35 inches, account for the rich supplies of good water in almost all the bores put down up to date.

It may be safely stated that the further development of the project will not be hampered by the lack of sufficient underground water of useful quality.

There is a tendency for the water, however, to become more saline with increasing depth, and efforts must be made therefore to make use of the top water of good quality.

Favourable locations for new bores are on high level sandstone country above the swamps, and the sites should be selected on cleared grassy country, in order to avoid the transpiration effect of vegetation on the quality of the water.

NORTH FRANKLAND PROJECT.

Traverses in the 200,000-acre North Frankland project have been confined to the Rocky Gully subdivision, the centre of which is situated in approximately Latitude $34^{\circ} 30' S.$ and Longitude $117^{\circ} 00' E.$

The area, which is underlain by granite gneiss, shows a gentle undulating land surface at an average elevation of about 800ft. above sea level. Considerable dissection of the country causes extreme variations in height of up to 300ft.

Outcrops of solid, impervious, gneissic granite are relatively frequent throughout the area, and surface evidence indicates that these rocks underlie the surface in most places at a relatively shallow depth. These facts obviously prevent efficient catchment of the rain water and its storage underground. Furthermore, the ridges which may act as possible catchments are in many cases a little more heavily timbered than is desirable.

Successful bore sites under such conditions depend very largely upon the configuration of the underlying granite. Surface indications, however, afford no information as to the position of granitic channels and depressions, and it will be necessary therefore to drill more than one hole in some places in order to locate these zones. A light prospecting plant, capable of boring about 200ft. would be most suitable for this purpose.

For immediate needs a water supply is required for seven selected house sites, and although possible boring locations have been indicated, the above considerations apply in each particular case.

In districts such as Rocky Gully, the whole planning must be governed by the problems of water supply, and the sites of houses have to be selected accordingly.

In conclusion it is pointed out that sand soaks are another possible source of water in the Rocky Gully district. Some of these soaks were seen in shallow depressions free from vegetation, and although large, permanent supplies cannot be expected, this type is worth testing in a naturally water poor country.

REPORT ON WATER SUPPLY ON KIMBERLEY CATTLE STATIONS.

By K. Berliat, D.Sc., M.I.Min.E. (Eng.)

INTRODUCTION.

The following report is based upon an examination of 24 cattle stations in the East and West Kimberleys, made by the writer during the period 15th May to 5th August, 1951, with the object of selecting additional sites for bores and wells.

The development of the pastoral industry in the Kimberleys hinges basically upon the provision of adequate and reliable water supplies. Lacking a sufficient number of artificial watering points (bores, wells, excavated tanks, etc.), spread rationally over suitable grazing country, cattle will concentrate along rivers and other permanent natural waters, with the result that large tracts of country become completely eaten out and the forces of soil erosion are given full sway. It is obvious that such conditions are detrimental to the natural increase of cattle, and represent the major cause of high mortality.

In order to halt the development of these unfavourable conditions, which are particularly acute in the East Kimberleys, a scheme for increasing watering points has been approved by the Government. The ultimate aim of this scheme will be to provide a watering point to serve every 28,000 acres of suitable grazing country, with the result that cattle will have a maximum distance of three and a half miles to walk to water.

The writer arrived at Wyndham on the 15th May, and from there travelled up the Ord River as far as Hall's Creek, visiting nearly all the cattle stations in the East Kimberleys. From Hall's Creek the journey followed the road to Fitzroy Crossing and Derby, and finally visits were paid to a few stations situated on the Northern Plateau, north of the King Leopold Ranges.

The writer is greatly indebted to pastoral companies and individual pastoralists for their assistance, co-operation, and unstinted hospitality.

PHYSIOGRAPHY AND CLIMATE.

The pastoral country in the Kimberleys is situated in the physiographic divisions Ord-land and Fitzroy-land (Jutson, 1914, and 1934), the two units corresponding approximately with what is generally known as East Kimberleys, and West Kimberleys.

The East Kimberleys show a marked difference in relief north of Argyle, the hills and ridges representing in all probability the remnants of an old, maturely dissected plateau. To the south, between Argyle and the Antrim Plateau, where the country is underlain by Cambrian basalts and sediments, the dominant topographical features are low lying, broadly undulating plains, forming excellent grazing land.

The East Kimberleys are drained by the Ord River and its tributaries, the most important of which are the Denham, the Bow, the Panton, and the Elvire Rivers.

The divide between the drainage systems of the East and West Kimberleys is approached in the vicinity of Hall's Creek. The Fitzroy River, and its main tributary, Christmas Creek, follow the regional north-westerly strike of the rocks. They control, together with the Margaret River, the primary drainage of the West Kimberleys.

The outstanding features in the relief of this area are a narrow belt of rugged limestone ranges, comprising the Napier, Oscar, Geikie, and Rough Ranges, in the northeast, and an extensive, comparatively low lying area, with scattered hills and ridges in the southwest.

The rainfall in the Kimberleys is of the summer monsoonal type. The average annual fall in the East and West Kimberleys is in the vicinity of 25 inches, but there are variations from 15 inches (Christmas Creek) to 35 inches (Carlton Hill).

Almost all the rainfall occurs from November to April.

THE ROCK TYPES AND THEIR WATER-BEARING PROPERTIES.

As far as can be ascertained the formations in the area under consideration vary in age from Pre-Cambrian to Recent.

Archean.—These comprise metamorphosed basic lavas, schistose greenstones, meta-sediments (slates, phyllites, mica schists), and granitic rocks. Their principal occurrences are in the East Kimberleys, where they form the bulk of the country between the Carr Boyd Range in the north and Mt. Dockrell in the south.

Proterozoic.—Nullagine formation. This series is made up essentially of a huge succession of sandstones, grits, quartzites, slates, and shales. The main occurrences are between Wyndham and the Denham River, in the Mt. Ramsay area, and north of the King Leopold Ranges.

Paleozoic.—Volcanic and sedimentary rocks include basalts, limestones, conglomerates, sandstones, and shales. Cambrian basalts and limestones predominate in the Ord River basin, south of Argyle. Ordovician, Devonian and Permian sediments underlie large areas in the West Kimberleys.

Tertiary.—Small remnants of lacustrine, fossiliferous marls and siltstones occur in the White Mountain Range (East Kimberleys).

Recent.—These deposits consist of alluvium (clay, silt, sand, gravel), soil, sand dunes, and laterite.

Considered from a hydrological angle the age of a certain rock type is immaterial. Whether a certain rock acts as an aquifer, i.e. whether it is able to absorb, store, and yield water or not, depends entirely upon its textural and structural features, in other words upon its mode of origin and geological history.

The writer has found that a great deal of misconception of the natural laws, controlling the origin, distribution, and quality of underground water exists, and that in consequence much expensive, useless work has been done.

It is fundamental to understand that underground water is stored in open spaces, existing in certain rock masses below the surface.

Basically these receptacles for water are of two different types:—

- (a) Interstices between individual rock grains.
- (b) Cavities due to fracturing, decomposition, or solution of the rock masses.

It is hopeless to search for water in any formation not offering at least one type of these openings.

The following is a summary of the most common rock types in the Kimberleys, and their water-bearing properties.

Granitic Rocks.

Water occurs in granitic rocks in two different ways, namely, in decayed and decomposed granite near the surface, and in joints and fissures in the deeper granitic formation.

Granite is one of the most easily altered crystalline rocks, and its disintegration products usually cover large areas of granite country. The residuum is as a rule sufficiently porous and disintegrated to afford storage for water. Good yields may be obtained where the residuum reaches a considerable thickness, and where there are favourable topographical conditions. An example for such a case is No. 4 bore on Lyssadell Station, where a good supply is obtained at a depth of 83ft.

Supplies in solid granite depend entirely upon the presence of joints. Prospects of finding a supply are a matter of chance and so poor as to be practically negligible.

Basalt and Associated Rocks.

From a hydrological point of view solid basalt is little better than granite, and much unsuccessful boring has been done in this type of country, especially in the East Kimberleys (Antrim Plateau, Bull Creek bores on Argyle). Boring in basalt is very hazardous, unless the sites are selected with great care. Water may occur in joints, in openings separating successive flows, in vesicular basalt, and layers of interbedded volcanic agglomerates. At Argyle several springs, such as Soda Spring and Napoleon Spring, providing large supplies, emanate through locally eroded areas, where underlying volcanic agglomerates are exposed. Another example where good supplies are obtained from basalt, is No. 13 bore on Gordon Downs. This bore which is between 500 and 600ft. deep, apparently draws its supply from vesicular and/or fragmental basalt at depth.

Phyllites, Mica Schists, Schistose Greenstones.

These rocks are as a whole unfavourable as sources of ground water. Horizontal jointing is exceptional in schists, but they show sometimes a marked development of vertical joints. Water may percolate through these openings and be stored in openings parallel to the schistosity. There is a tendency, however, for all these openings to be closed at a relatively shallow depth, on account of the softness of most schistose rocks.

Good supplies may be obtained in sheared and crushed zones due to major faulting.

Clay, Shale, Slate.

Although pure clay has a high porosity, it is, on account of the minuteness of the interstices, absolutely impervious under ordinary hydrostatic pressure, and forms thus the most hopeless deposit as a source for water supply.

Shales and slates are formed by the induration of clay and clayey mixtures, and offer as a whole very unfavourable underground water conditions. Useful water may be stored in joints and fissures, and along bedding planes.

Several bores on Glenroy Station may serve as typical examples for this type of supply.

Sand, Gravel, Sandstone, Conglomerate, Quartzite.

The value of these rock types as aquifers depends on the size of grain, the degree of assortment, and the degree of cementation.

The size of grain is immaterial as far as porosity is concerned. All other things being equal a sand has about the same porosity as a gravel. The permeability however, i.e., the capacity of conducting and yielding water, of a fine sand with very small interstices compares unfavourably with that of a coarse sand or a gravel.

The amount of variation in size of grain or the degree of assortment is of fundamental importance with regard to porosity. Well sorted deposits, consisting of uniform size of grain have high porosity, poorly sorted deposits, composed of a mixture of grains, have low porosity.

Cementation and resulting consolidation affect the deposit in that they close the interstices between the individual grains. A moderate amount of cementation, however, may improve a sand by making it more coherent and less likely to run into a well or bore.

Coarse, clean, well sorted gravel is an excellent formation to yield water. Sand and loosely cemented sandstones rank next. In indurated sandstones, firmly cemented conglomerates and quartzites all the original interstices have been closed, and joints afford the only storage room for water.

Limestone and Related Rocks.

The degree to which a limestone acts as an aquifer depends mainly on the extent to which it has been subjected to the solvent action of percolating waters. Old limestones are generally compact and impervious, but large supplies can be obtained from solution cavities, formed along joints and bedding planes by percolating waters charged with carbon dioxide.

Although the search for water in a creviced formation naturally involves a large element of chance, the instances of failure in the Paleozoic limestones of the Kimberleys are extremely low. The Cambrian limestones of the Argyle and Rosewood basins yield excellent supplies in a number of bores. Typical examples are the Newry Gate bore on Argyle, and Number 1, 2 and 3 bores on Lyssadell. The depth of these bores varies from 103 to 681ft. and supplies range from 800 to 1,500 gallons per hour.

TOPOGRAPHICAL AND STRUCTURAL INFLUENCES ON GROUND WATER.

The very important influence of the topography on ground water conditions lies in the fact that it governs the disposal of the run-off portion of the rainfall and the probable salinity of the ground water. Attention must be paid to the extent of local catchment areas, and to the nature of the channels through which the run-off must pass.

The structural conditions bearing upon the distribution of ground water are especially the type and degree of jointing and the occurrence of faulting. Faults may act as subterranean dams, or as conduits and containers for ground water. Folding, especially in limestone country, may lead to fracturing and jointing of the strata involved, and thus afford storage room for ground water. An impounding effect on percolating waters, similar to certain faults, may also be brought about by intrusive dykes. This is particularly important where a dyke crosses a water channel or a valley.

SITES FOR BORES AND WELLS SELECTED ON KIMBERLEY CATTLE STATIONS.

In the following pages a summary description is given of the sites selected on the various cattle stations. The approximate position of these sites is marked on the accompanying map.

These sites will cover the needs for immediate improvements. Apart from that other suitable areas for underground water have been indicated; they may be considered for further development.

It has been pointed out to pastoralists that many of the sites selected are a proposition for wells with horizontal drives, rather than for bores, and some sites are exclusively a well proposition. This applies particularly to stations like Mabel Downs and Alice Downs, the grazing country of which is largely underlain by greenstones and metasediments. Here, in the absence of other sources valuable supplies may be obtained in wells, especially along creeks. The same applies to various sites selected in the Nullagine formation and in decomposed granite. It is obvious that potentially water-bearing formations of this type are in a great many cases unable to yield the large supplies required on cattle stations from small diameter bore holes.

No. 1. Ivanhoe Station.—Site in Devonian Cockatoo Sandstones, near the faulted contact with Cambrian basalt (black soil). Dip of the sandstones 10 deg. S.E.

No. 2. Ivanhoe Station.—Site in thick sandy alluvium, on the bank of the Keep River. Alluvium underlain by Cockatoo Sandstones, dipping 8 deg. S.E.

No. 3. Ivanhoe Station.—This alternative site is three to four miles south of No. 2, in Keep River alluvium. A range of bare hills and ridges near the Northern Territory border forms an excellent catchment area.

From the standpoint of the pastoralist No. 2 site is preferable, as No. 3 is only three miles north-north-west from Milligan Billabong (Northern Territory).

No. 4. Ivanhoe Station.—Site in fractured limestones of the Devonian Burt Range Series.

No. 5. Ivanhoe Station.—Site on the bank of Clean Skin Creek. Large development of sandy alluvium, underlain by jointed quartzites of the Nullagine formation.

No. 6. Argyle Station.—Site in jointed limestones of the Cambrian Negri Series, dipping 10 deg. W., towards the centre of the Argyle basin.

No. 7. Argyle Station.—Limestones of the Negri Series. The site is near the banks of Hicks Creek, just outside the reach of the flood waters.

No. 8. Argyle Station.—Site in fault zone between Mt. Brooking Series (Permian) and basalt (Cambrian). The hills near Donkey Gap form a good local catchment area.

No. 9. Argyle Station.—Site selected to draw water from the Girvanella limestone (Negri Series) at depth.

No. 10. Carlton Hill Station. Highly jointed quartzites and sandstones (Nullagine). Site in a gully, concentrating the run-off from a large catchment area.

No. 11. Dunham River Station.—Site on the eastern bank of the Dunham River. Alluvium, underlain by jointed Nullagine sandstones.

No. 12. Dunham River Station.—Site in low lying area, with good local catchment. Nullagine formation.

No. 13. Dunham River Station.—Site at the foot of a highly decomposed granite ridge.

No. 14. Dunham River Station.—Site on the bank of Macphee Creek, just above a conspicuous valley constriction, brought about by the appearance of hard, massive sandstones and conglomerates in the Nullagine Series.

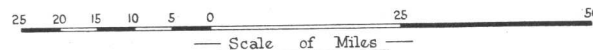
No. 15. Dunham River Station.—Site in thick, red, sandy alluvium on the bank of Macphee Creek.

No. 16. Dunham River Station.—Similar, alternative site on the bank of Macphee Creek.

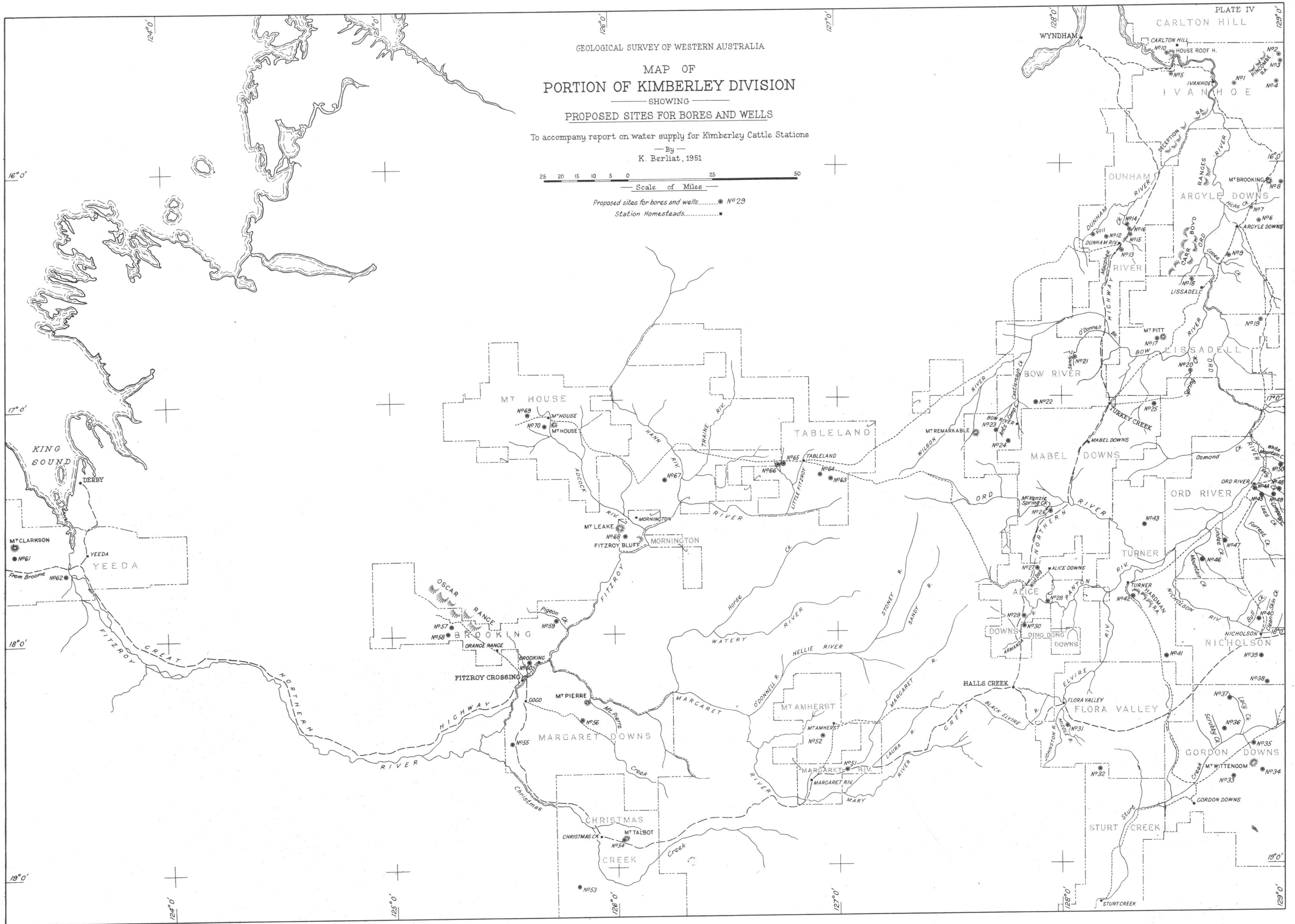
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
MAP OF
PORTION OF KIMBERLEY DIVISION
SHOWING
PROPOSED SITES FOR BORES AND WELLS

To accompany report on water supply for Kimberley Cattle Stations

By
K. Berliat, 1951



Proposed sites for bores and wells..... No 29
Station Homesteads.....



- No. 17. Lissadell Station.—Jointed and fractured quartzites and ferruginous sandstones (Nullagine). Site near the foot of Mt. Pitt, forming excellent catchment.
- No. 18. Lissadell Station.—Site in red, ferruginous sandstones, interbedded with white, sandy shales (Mt. Brooking Series?).
- No. 19. Lissadell Station.—Site in limestones of the Negri Series. A very conspicuous "limestone wall" forms the boundary between basalt and Negri Series.
- No. 20. Lissadell Station.—Site near the bank of Spring Creek, in jointed Cambrian basaltic rocks.
- No. 21. Bow River Station.—Site at a distance of 30 yards from the eastern bank of Sandy Creek. Sandstones, sandy shales and jointed quartzites are outcropping in the creek bed. Dip 40 degr. E.
- No. 22. Bow River Station.—Site close to a creek between two ridges formed by fractured granite. There is a considerable thickness of decomposed granite on the slopes, and on the floor of the valley.
- No. 23. Bow River Station.—Site in alluvium and decomposed granite, about 1 chain from the bed of "Ant Camp" creek. Good local catchments.
- No. 24. Bow River Station.—Site above a conspicuous and continuous acid dyke. The dyke appears in a depression, which is drained by a gully. The country above the dyke is gradually rising, and is underlain by decomposed granite.
- No. 25. Mabel Downs Station.—Site close to the bank of a creek in "Moonlight Valley." Sandy shales and slates with well developed cleavage planes and vertical joints.
- No. 26. Mabel Downs Station.—Site in alluvium on the bank of McKenzie Spring Creek.
- No. 27. Alice Downs Station.—Site in alluvium on the bank of Togo Creek.
- No. 28. Alice Downs Station.—Site in alluvium on the bank of the Panton River.
- No. 29. Alice Downs Station.—Site in alluvium on the bank of Emu Creek.
- No. 30. Ding Dong Downs Station.—Site in thick, sandy alluvium on the bank of the Armanda River.
- No. 31. Flora Valley Station.—Site one chain from Middle Creek. Alluvium, underlain by sandstones and jointed quartzites (Nullagine).
- No. 32. Sturt Creek Station.—Site in sandstones and jointed quartzites of the Nullagine formation, near the contact with Cambrian basalt.
- The Nullagine Series weathers to a red, sandy soil, carrying a rich vegetation (white gum), while the basalt produces a heavy, black soil, devoid of all vegetation.
- No. 33. Gordon Downs Station.—Site as No. 32.
- No. 34. Gordon Downs Station.—Site in a heavily timbered, low lying area between two marked ridges, forming ideal catchment. Nullagine formation.
- No. 35. Gordon Downs Station.—Site in thickly timbered, red, sandy soil, derived from underlying Nullagine sandstones.
- No. 36. Gordon Downs Station.—Site as No. 32.
- No. 37. Gordon Downs Station.—Site in thick alluvium of Lazy Creek, not far above a well marked valley constriction, caused by hard, gritty sandstones and compact conglomerates (Nullagine). Good catchment area.
- No. 38. Nicholson Station.—Site close to Alice Creek. Exposures of grey sandstones, sandy shales, and limestones.
- No. 39. Nicholson Station.—Site as No. 35.
- No. 40. Nicholson Station.—Site on the bank of Pear Tree Creek, in decomposed and jointed basalt, amygdaloidal and vesicular basalt.
- No. 41. Turner River Station.—Site as No. 32.
- No. 42. Turner River Station.—Site four chains from the bank of the Turner River. Alluvium, underlain by limestones of the Negri Series.
- No. 43. Turner River Station.—Site in sandstones of the Mt. Elder Series (Cambrian).
- No. 44. Ord River Station.—Site on the bank of Forrest Creek. Negri Series: Limestones, sandy shales.
- No. 45. Ord River Station.—Site two chains from Forrest Creek, just below the junction of Forrest Creek and Company Creek. Jointed limestones, dipping 8-10 degr. N. Negri Series.
- No. 46. Ord River Station.—Site in limestones of the Negri Series.
- No. 47. Ord River Station.—Site close to Linacre (Lindee) Creek. Negri Series.
- No. 48. Ord River Station.—Site in a zone of springs on the eastern bank of Kelly Creek. Limestones, dipping 5 degr. N.W. Negri Series.
- No. 49. Ord River Station.—Site near Company Creek. Geological conditions similar to those at No. 48.
- No. 50. Ord River Station.—Site in faulted and fractured limestones, close to White Mountain Creek. Negri Series.
- No. 51. Margaret River Station.—Site about one chain from the southern bank of the Margaret River. Nullagine formation.
- No. 52. Mt. Amherst Station.—Site in Nullagine Series, above a well defined valley constriction.
- No. 53. Christmas Creek Station.—Two bores have been put down at a distance of about 20 miles S.S.W. of Christmas Creek Homestead. Both of them struck saline water at shallow depths. From the bore sites, which are situated in a depression, the country gradually rises westwards, to form a broad plateau, underlain by sandstones of probably Permian age. Site No. 53 has been selected high up the slope, about half a mile to the west of the salt bores. In case the water should still be saline, an alternative site, near the top of the plateau has been indicated.
- No. 54. Christmas Creek Station.—Site in ferruginous Permian sandstones.
- No. 55. Margaret Downs Station.—Site near "Sugarbag Billabong," close to the bank of Nipper Creek. Ferruginous sandstones and grits of Permian age (Liveringa/Noonkanbah formation).
- No. 56. Margaret Downs Station.—Site in Devonian Pillara limestones.
- No. 57. Brooking Springs Station.—Site on the southern bank of 12-Mile Creek, in Bugle Gap limestones (Devonian).
- No. 58. Brooking Springs Station.—Alternative site two and a half to three miles south of No. 57. Geological conditions are analogous.
- No. 59. Brooking Springs Station.—Site in undifferentiated Devonian limestones, close to Pigeon Creek.
- No. 60. Brooking Springs Station.—Site in Bugle Gap limestones (Devonian).
- No. 61. Yeeda Station.—Site in ferruginous sandstones and grits (Permian).
- No. 62. Yeeda Station.—As No. 61.
- No. 63. Tableland Station.—Site in a zone of springs, emanating from decomposed and jointed basalt and vesicular basalt.
- No. 64-66. Tableland Station.—Sites in ferruginous sandstones, grits and jointed quartzites of Nullagine age.

No. 67-68. Mornington Station.—As No. 64-66.

No. 69. Mt. House Station.—Site in red ferruginous sandstones.

No. 70. Mt. House Station. Site in greenish sandy shales, near the bank of a creek.

In conclusion reference is made to the paucity of information regarding most of the boreholes that have been drilled in the past. It is urged that a full and proper record should be kept of all future boring operations. For each borehole or well, whether successful or not, this record should give full particulars concerning:

1. The exact position.
2. The altitude above sea level and above surrounding country.
3. The log of the borehole with samples of rocks penetrated.
4. The total depth.
5. The depth at which each water was struck.
6. The thickness and the yield of each aquifer.
7. The quality of the water.

REPORT ON LOCATION OF BORE SITES FOR WATER AT LAKE ALLANOOKA.

By K. Berliat, D.Sc., M.I.Min.E. (Eng.)

INTRODUCTION.

The Geological Survey has been requested to assist in the location of two exploratory water bores in the sand plain adjacent to Lake Allanooka.

Lake Allanooka is situated in approximately Latitude 29°0' S. and approximately Longitude 115°0' E. The locality is easily accessible by car or truck from the small township of Walkaway, 20 miles by road from Geraldton. The distance from Walkaway to Lake Allanooka is 24 miles.

Lake Allanooka occupies a small portion near the northern edge of an oval shaped basin of say six or eight square miles, the longer axis of which points roughly north and south. The depression is surrounded on all sides by high level sand plain country. The difference in elevation between the top of the sand plain and the floor of the basin is about 400ft. along the northern and north-western rim, but is considerably less on the south and south-east. The basin has no surface outlet but the possibility of subterranean drainage to the west cannot be discarded a priori.

The water level in the lake is subject to fluctuations, but it is stated that the lake never goes entirely dry. The water is of good quality, having a content of about 47 grains per gallon. A marked increase is noticeable towards the end of the dry season. The area receives an average annual rainfall varying from 16 to 18 inches.

The country rocks are predominantly quartzitic or feldspathic grits, and white, yellow or red sandstones, with some intercalations of sandy shales and clays. The formation shows a slight regional dip to the west, and is regarded tentatively as Jurassic.

Porous rock types and suitable topographic conditions render the area potentially water-bearing. The crux of the matter will be to ascertain the salinity of the ground water, and therefore the principles governing the relations between fresh and salt water were given special attention. No. 1 site has been selected in comparatively low lying country, while No. 2 site is 150ft. vertical distance higher up the slope.

It is of interest to note that the general conditions at Lake Allanooka exhibit a marked similarity to those existing in the Wicherina basin (27 miles by road east of Geraldton), from which Geraldton draws its water supply.

Irwin Springs—Ground Water Possibilities.

The Irwin Springs are located in the valley of Springy Creek, a tributary of the Irwin River, one mile east of Irwin homestead, and 14 miles by

road from Dongara. They issue in a low, water-logged tract, about one chain south of the main road from Geraldton to Perth. There are two vents, and pumping tests on one of them, carried out recently by the Public Works Department, showed a yield of 1,700 gallons per hour. The springs have therefore been considered as a possible source of supply for Dongara and Denison.

The Irwin Springs belong to the class "Gravity Springs" or "Filtration Springs" (U.S. Geol. Surv., Water Supply Paper 494). The country rocks consist predominantly of porous Jurassic sandstones, underlying both the high level sand plains to the north and the ridges to the south. The configuration of the topographic surface, being related to that of the water table, brings about an outcrop of the latter in the zone of seepage.

The opinion is expressed that testing of the area has very good chances of success. It is stated that the bore put down by the Midland Railway Company, two or three chains away from the springs, yields an unlimited supply.

REPORT ON LAVERTON SCHEELITE PROSPECT P.A. 2548T, P.A. 2554T, P.A. 2555T, LAVERTON, MT. MARGARET GOLDFIELD.

Approx. Lat. 28°05' S.

Approx. Long. 122°15' E.

By K. Berliat, D.Sc., M.I.Min.E. (Eng.)

Location.

The prospecting areas for scheelite are situated 45 miles by road north of Laverton, and about half a mile east of the road from this township to Eristoun.

Geology.

The country rocks in the immediate vicinity of the deposit consist of schistose greenstones, granitised schistose greenstones, and intrusive quartz dykes. The granitised greenstone schists with the undigested remnants are highly sheared and foliated. They have an average strike of N.10°W. and an average dip of 78°E.

The Scheelite Occurrences.

Scheelite mineralisation shows a definite association with quartz, and is confined to a linear zone between granitised greenstones and a narrow band of unaltered greenstone schists. Mineralisation along this line is not continuous, but patchy and extremely irregular. At the time of inspection (November 1951) six productive quartz lenses occurring over a maximum distance of 1,320ft., have been worked. They vary in thickness from 2ft. 6in. to 8in. and exhibit a maximum length of 100ft. (extreme south end of P.A. 2548T.).

In some instances mineralisation has taken place in granitised greenstones, adjoining to quartz lenses. In this case the rock is veined with a network of parallel or anastomosing stringers and veinlets of quartz, and the mineral occurs in patches or as disseminated grains.

Prospects of the Deposit.

Up to the date of examination prospecting and mining activities have been confined to P.A. 2548T. A first parcel of nine tons of ore from trenches and shallow shafts (maximum depth 25ft.) has been crushed at the State battery at Coolgardie and yielded a total of 565lb. of concentrates.

Heavy soil covering on the adjoining prospecting areas to the north and south (P.A. 2555T, and P.A. 2554T) makes any observations impossible. It may be safely stated, however, that, even if mineralisation extends in these directions, it will also be patchy and irregular in occurrence.

In conclusion I have no doubt in saying that the deposit has no prospects for large scale development, but with the present demand and the high price for tungsten further development of the show as a "prospector's proposition" is justified.

REPORT ON COPPER PROSPECT P.A. 2242, NORSEMAN, DUNDAS G.F.

Approx. Lat. 32°05' S.; Approx. Long. 121°40' E.

By K. Berliat, D.Sc., M.I.Min.E. (Eng.).

Location.

The copper occurrences are situated about seven and three-quarter miles by road north-north-west of Norseman, and about three-quarters of a mile west of the main road from Norseman to Coolgardie. P.A. 2242, applied for by Messrs. T. F. Egan and C. Mitchell, lies on Native Reserve No. 22465 (19,745 ac.), and on this account an objection to the application has been lodged by the Commissioner of Native Affairs. Under these circumstances the Warden has required a geological report on the find, before granting any title on the ground.

General Geology.

Medium to fine grained basalts are outcropping on the western half and to the west of P.A. 2242. Adjoining the basalt to the east is a narrow belt (about 100ft.) of metamorphosed sediments, consisting mainly of banded ironstones and graphitic schists. The average strike of the sediments is a few degrees to the east of north and the dip is high and to the west (average 72°).

Bounding the sediments to the east, and evidently intruding them, are coarse grained gabbroid rocks, forming a low ridge. A quartz "blow" occurs near the north-eastern corner of the prospecting area.

The Copper Occurrences.

Interformational copper mineralisation, evidently associated with the intrusion of the basic magma, has taken place in the altered sediments. The ore-carrying matrix is a more or less siliceous ironstone. It contains malachite and small quantities of azurite.

The lode, whose trend is coincident with the strike of the country rocks, has been opened up by three narrow costeans, having a maximum depth of two feet. The two southern costeans, which are very close together, are at a distance of about 125ft. from the northern costean. As seen in these costeans copper mineralisation occurs over a width varying from four to five feet.

Such surface evidence as is available indicates that mineralisation has taken place in a small lenticular area only, and that the lode does not extend very far beyond its presently known limits.

Two specimens of particularly rich appearance have been forwarded to the Government Chemical Laboratories for assays for copper and gold.

The specimen collected from the north costean assayed 10.35 per cent. copper, while that from the south costean assayed 10.62 per cent. copper.

There is no gold in either of the samples.

Conclusion.

The conclusions to be arrived at from the evidence available are:—

1. The extent of copper mineralisation is limited and too small to be of commercial value.
2. The deposit as a whole is of low grade character.

REPORT ON A GOLD FIND ON P.A. 6543, COOLGARDIE.

By K. Berliat, D.Sc., M.I.Min.E. (Eng.).

Location and General Information.

P.A. 6543 is situated in the Camel Paddock, some four miles north-east of Coolgardie Town, and just over a mile north-north-west of the 4-mile peg on the Coolgardie-Kalgoorlie road. The place is easily accessible by a bush track, branching off from the main road at a distance of about 150 yards after the 4-mile peg.

A rich gold find has been made recently on this P.A. by Messrs. M. Brown and W. Hart. At the time of the examination there was one shaft, totalling 30ft. in vertical depth. Two 7cwt. parcels of ore, treated on the 20th and 27th November, 1951, yielded 890 oz. and 509 oz. of gold respectively.

General Geology.

The country in the vicinity of the find is of low relief and there are no natural outcrops. Regional mapping has shown that the area is on the eastern limb of the major Coolgardie structure and lies on a minor cross-fold axis. The country rocks, as exposed in the shaft, consist of ultrabasic, schistose greenstones. The strike of the schistosity varies from S. 70° E. to east and west and the dips are vertical.

Within the greenstones, and coincident with their strike and dip, there is a zone of highly sheared rocks, consisting of talc schists, chlorite schists, and micaceous schists, together with ultrabasic decomposition products showing all the transitions from an unaltered schist to a hard, compact, jasperoid ironstone. It is in this shear zone, which varies in thickness from half an inch to six inches, that gold mineralisation has taken place.

The gold values occur in shoots or patches. The richest patches, yielding almost the total of the gold obtained so far, were encountered at a depth of 18 to 23ft., and very rich ore is worked at present at the bottom of the shaft*.

Mineralisation.

Investigations carried out by the Geological Survey of Western Australia in both the Yilgarn and Coolgardie goldfields have demonstrated the fact that—given a suitable host rock—gold mineralisation is controlled by structural conditions. The occurrences in the Camel Paddock are no exception to this principle. Tight regional folding, together with cross-folding were the cause of high fracturing and shearing in the ultrabasic schists, and especially in their least competent members, the talc and chlorite schists. The ore-bearing solutions or vapours have been able to use these easily penetrable zones in the original formation for their passage, and the precipitation of gold has been made possible by the high iron content of the host rock.

The patchy occurrence of the gold values in the lode seems to indicate that a considerable amount of secondary enrichment has taken place, and therefore a decrease in values may be expected at depth. At this stage lateral prospecting on higher levels may prove to be successful.

* According to a newspaper report (*The West Australian*, 19th December, 1951) a 6½ cwt. parcel of this ore yielded 600 oz. 2 dwt. of gold.

REPORT ON G.M.L. 462, LOC. 53, HAMPTON PLAINS, COOLGARDIE, COOLGARDIE G.F.

By K. Berliat, D.Sc., M.I.Min.E. (Eng.).

General.

The 24 acre lease, held by Messrs. G. P. and A. G. Frank, is situated approximately 18 miles by road E.S.E. of Coolgardie townsite, and approximately seven miles E.N.E. from the 11 mile peg on the main road from Coolgardie to Norseman and Esperance. At the time of the examination (13th December, 1951) there were two shafts, 240 feet apart in a north-south direction. The vertical depth of the southern shaft was about 12 feet, while the northern shaft totalled 25 feet.

A first parcel of 3 cwt. of ore, treated at the Coolgardie State Battery (27th November, 1951) yielded 139 oz. of gold. The bulk of the values (about 120 oz.) was obtained from a small portion at the bottom of the north shaft.

General Geology.

The lease is located in an area of ultrabasic schistose greenstones, predominantly actinolite and tremolite schists, which strike S.20°E., and dip steeply (average 78°) E.N.E. The series is strongly foliated and sheared and has been intruded by quartz reefs.

The Gold Occurrences.

The rich patch of gold in the north shaft occurs in altered greenstone schists, containing chlorite, talc and nontronite as predominating minerals. The values are associated with an interformational band of graphitic schists. The thickness of this "leader" averages 18 inches and is conformable in

strike and dip with the country rocks. The gold is found in the hanging wall, adjacent or very close to the graphitic layer. A gradual increase in values was noticeable from the surface to the bottom of the shaft.

There is no indication so far of the presence of the graphitic horizon in the south shaft, where the values occur in actinolite- tremolite schists. Up to the date of the examination 6 oz. of gold have been obtained from this shaft.

The writer has been informed by Mr. G. P. Frank, that prospecting by normal loaming methods revealed the presence of gold over a total length of 600 feet. This figure includes the distance between the shafts and additional distances of about 180 feet to the north and south.

Conclusions.

Further work will have to be done before the extent of the discovery can be gauged. Secondary enrichment is evidenced by the uneven distribution of the high values. This means that the latter cannot be expected to continue with depth.

Further prospecting with the object of determining the lateral extent of the ore shoot within the zone of oxidation is recommended.

REPORT ON DIAMOND DRILLING FOR CHROMITE AT COOBINA—NORTH-WEST LAND DIVISION, Approx. Lat. 23°31' S., Approx. Long. 120°19' E.

By L. E. de la Hunty, B.Sc.

INTRODUCTION.

The deposit is situated 258 road miles north of Meekatharra and about three miles west of the Great Northern Highway. It outcrops on the south-east corner of the Hamersley-Ophthalmia Plateau which is bounded by very steep slopes.

Money for the diamond drilling of this deposit was made available by the Commonwealth Government and drill sites were laid out by Mr. R. S. Matheson of the Bureau of Mineral Resources.

Supervision of the drilling was undertaken by the State Mines Department and the writer was sent to do this work—arriving at Coobina on November 1st.

Inspection of the proposed drill-sites revealed them to be absolutely inaccessible to a motor vehicle until such time as a road was made up to the top of the plateau. DDH No. 1 was sited as the only possible alternative hole and drilling operations commenced on November 3rd.

On completion of this hole (25 Nov., to a depth of 200 ft.) drilling was suspended, pending—(i) The construction of a road to the top of the plateau. (ii) Purchase of a lighter drilling plant.

Under these conditions sites Nos. 1, 2, 3, 4, 5, 8, as selected by R. S. Matheson, should be accessible for drilling. Sites Nos. 6 and 7 are inaccessible without expensive road making.

DDH No. 1

Location—

300ft. S.46°E. of West corner peg of M.C. 41P.

Azimuth of Hole N.36°W.

Angle of Depression 40°.

Size of Core—AX.

Water Used—Average of 200 gallons per day.

Results—(See Log)

0ft.—50ft.	Gr/gn.
50ft.—52½ft.	Quartz.
52½ft.—156½ft.	Serpentine.
156½ft.—180ft.	Chromite with bands of serpentine.
180ft.—200ft.	Serpentine.

Vertical depth of intersection of ore body below outcrop = 145 ft. (Hanging wall intersection).

Dip of Hanging Wall—approx. 75°.

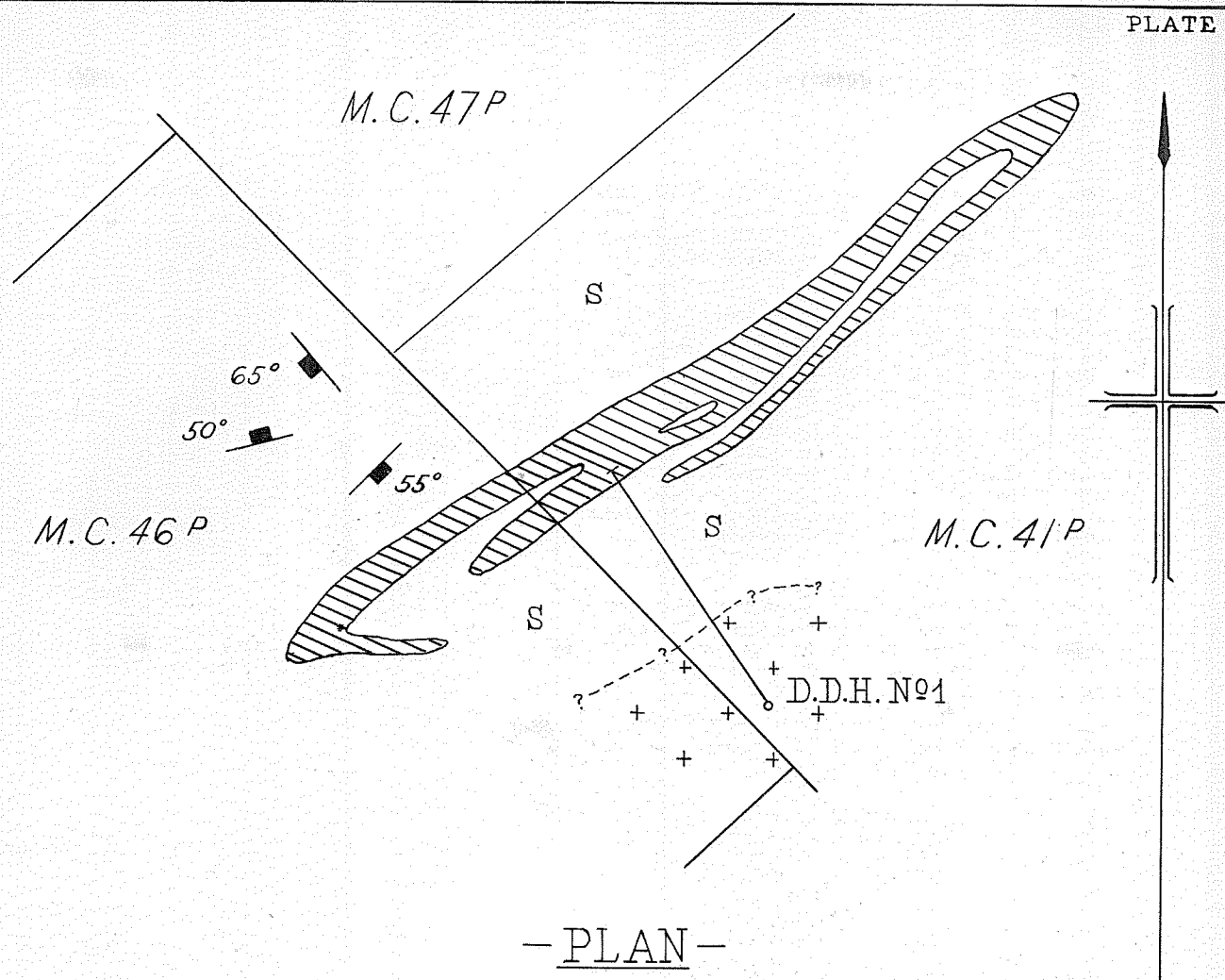
COOBINA CHROMITE.

DDH No. 1. 300 ft. S 46°E of W. corner peg of MC 41P.

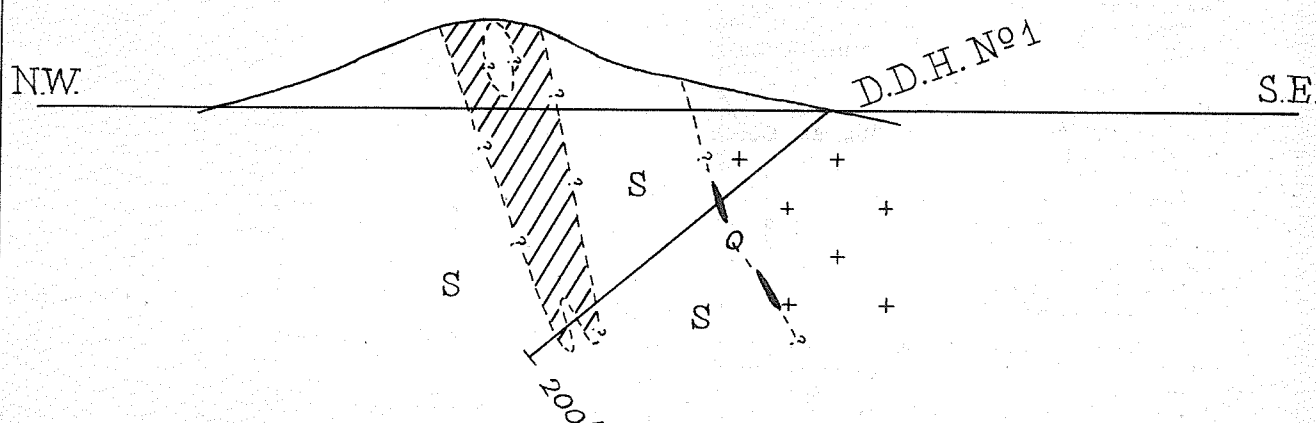
Azimuth of Hole N 36°W.

Angle of Depression 40°.

Pull.		Total Core Re- covered.	Detailed Description.
From.	To.		
(Feet.)	(Inches.)		
0	1	12	Loam soil and rubble.
1	3	5	Red gneissic granite boulders on hill slope giving way to a fractured gr/gn with traces of epidote and some serpentinous material.
3	4	2	The country rock is much fractured.
4	6	2½	
6	8	7	
8	10	5	
10	12	8	Same gr/gn but rather more amphibole in the core.
12	21	13	
21	23	18	
23	25	9½	
25	28	13	
28	30½	4	
30½	32½	3	
32½	34½	4	
34½	38	10	
38	41	5½	
41	42	7	26 in. gr/gn ; 2½ in. greenish quartz. Quartz. Quartz. 3 in. Quartz. 18 in. Green serpentine containing chromite and shot through with veinlets and thin stringers (1/16 in. — 1/8 in.) of calcite. At 80 ft., there are small calcite vugs also faults and fault breccia recemented with calcite. Serpentine with calcite and chromite. (Drillers say machine did not core from 92 ft. to 96 ft.—perhaps calcite.)
42	50	28½	
50	51	1½	
51	52½	4	
52½	70	21	
70	74	35	
74	85	55	
85	96½	48	
96½	100	19	
100	104½	51	
104½	115	101	Green serpentine with chromite and calcite. 30 in. Serpentine with chromite and calcite. 1 in. Chromite with serpentine. 13 in. Jointed serpentine with chromite. 2 in. Pale green bare serpentine. (Started losing water at 124 ft. due to joints and calcite.) 2 in. Serpentine with chromite and calcite. 3½ in. Calcite with lumps of chromite. 10 in. Serpentine with chromite. 2 in. Serpentine with chromite. 1 in. Quartz. 6 in. Serpentine with chromite. 22 in. Serpentine with chromite. 1 in. Chromite. 7 in. Serpentine with chromite. Small amount of (?) chrysotile in sludge. Serpentine with 1 in. stringers of chromite. Serpentine with chromite, veinlets of calcite with chrysotile and some pyrite at 150 ft. Serpentine with bands of CHROMITE and some calcite. Disseminated Ore.
115	118	7	
118	121½	31	
121½	124½	15	
124½	133	15½	
133	135	9	
135	143	30	
143	149½	59	
149½	151	18	
151	156½	36	



— PLAN —



— SECTION THROUGH D.D.H. No 1 —

Intersection of Chromite 145' V.D.
Azimuth of Borehole N36°W
Angle of Depression 40°

— REFERENCE TO SIGNS —

Gr/Gn ++
Chromite Ore-body
Quartz Q
Serpentine S

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
COOBINA — CHROMITE DEPOSITS

D.D.H. No 1

Scale :- 100 feet to inch

Geology by L. E. de la Hunby, B.Sc. Nov. 1951.

COOBINA CHROMITE—continued.

Pull.		Total Core Re- covered.	Detailed Description.
From.	To.		
(Feet.)	(Inches.)		
156½	157	Nil	? Calcite.
157	163¾	27	16 in. Chromite.
			1 in. Calcite—may represent 3 ft. of calcite. 10 in. Chrom- ite.
163¾	172½	23	Chromite with serpentine and some calcite.
172½	175¾	32	24 in. Chromite.
			8 in. Pale green bare serpen- tine.
175¾	177⅝	24	11 in. Pale green bare serpen- tine.
			13 in. Chromite.
177⅝	179¼	16½	1 in. Chromite.
			15½ in. Serpentine.
179¼	189½	111	Serpentine with scattered chromite and some calcite.
			do. do. do.
189½	200	43	
Total Core		989½	

Notes on Core Recovery:

1. Overall percentage core recovery = 41.2%.
2. This low percentage recovery is no doubt due to the broken country and soft seams met with.
3. Extreme care was taken as can be seen by the lengths of the various runs.
4. The first 70ft. of drilling proved very rough on bits (one particular bit only lasting 2½ft.).

Sampling.

The core was sampled in 5ft. lengths from 151½ft. to 182ft. The samples were analysed by the Government Chemical Laboratories.

Results of Assays—

Sample No.	Bore Depth.	Chromic Oxide, Cr ₂ O ₃ Per Cent.
GS/C1	151½ft.—157ft.	15.40
GS/C2	157ft.—162ft.	42.67
GS/C3	162ft.—167ft.	35.09
GS/C4	167ft.—172ft.	26.89
GS/C5	172ft.—177ft.	25.60
GS/C6	177ft.—182ft.	10.61

Samples GS/C1 and GS/C6 are classed as "dis-seminated ore" while GS/C2-5 are representative of the ore body. Over this 20ft. the average grade is 32.56 per cent. Although this 20ft. is the length in the bore, it differs very little from true width of the ore body.

CONCLUSIONS.

1. This chromite lens persists to a vertical depth of at least 150ft. (See accompanying plan and section).
2. Grade at this depth is lower due to patches of serpentine in the ore-body. Average grade at the surface is about 47 per cent., Cr₂O₃. Grade at 150ft. is 32.56 per cent., Cr₂O₃.
3. True width of ore-body at 150ft. is approximately 20ft.
4. Dip of ore-body—75° to south east.
5. Since the intersection with the ore-body was less than 200ft. from the southern extremity of the lens, this hole seems to prove that there is every likelihood that the larger lenses, at least, will persist to a vertical depth of 150ft.

REPORT ON PEGMATITE AT SPARGOVILLE,
COOLGARDIE G.F.

Approx. Lat. 31° 14' S.; Approx. Long. 121° 28' E.

By L. E. de la Hunt, B.Sc.

Introduction.

The area mapped is about one mile south of Spargoville and about 30 chains west of the Coolgardie-Esperance road. M.C. 9 and P.A. 6449 cover the area.

The reason for mapping was to determine the structure of the pegmatite and to recommend further prospecting and development.

Valuable assistance was given the writer by Mr. A. S. Giles, the owner of the claim. He has had considerable experience with pegmatites and was able to supply a lot of information about the deposit. He also carried the staff.

Method of Survey.

The survey was made on a scale of 100ft. to an inch—using plane table and telescopic alidade.

The pegmatite was mapped strictly on outcrop only. Where the boundaries were difficult to distinguish—due to boulders on the slope of the hill—a "doubtful or assumed" boundary was marked. Occurrences of the minerals Columbite, Beryl, Tourmaline, etc., are shown.

Sections were drawn (10ft. to an inch) through the only two places where a true measurement of the dip of the hanging wall could be made.

General Geology.

The area is one of Pre-Cambrian greenstones, banded quartz iron formations (Q.Fe.) and pegmatite with quartz lenses. Soil cover obscures much of the geology.

The greenstones consist of a coarse grained amphibolite (anthophyllite), a medium grained massive rock and a highly schistose greenstone. No attempt was made to differentiate these when mapping.

Interbedded with these greenstones is the banded quartz iron formation (Q.Fe.) which forms a prominent ridge to the west of that formed by the pegmatite. Some dragfolding was seen to occur in the Q.Fe. but this may have been due to slumping in the original sediments before metamorphism. The Q.Fe. includes hematite quartzite, quartzite, chert, and a fine hematite schist (on its western edge).

The pegmatite is intrusive in a direction generally parallel with the schistosity of the country rock but changes in direction of at least 40° can be seen. It seems the greenstone may be folded—giving curved lines of weakness—but no evidence of this could be obtained from the exposures. Many of the outcrops of schist on hill slopes gave different readings of strike and dip but these were not considered reliable.

The Pegmatite.

The pegmatite is very coarse in character and consists of the potash felspar Microcline, the soda felspar Albite, Quartz, Muscovite, and accessory minerals—Tourmaline, Columbite and Beryl.

Columbite is the main economic mineral but marketable quantities of beryl are also won.

Zoning is most marked on the hanging wall of the pegmatite body (see sections).

Section AB shows a 5ft. thickness of albite on the hanging wall—in two zones. The first 2ft. is made up of albite and microcline felspars with tourmaline (2ft. long) as an accessory. This zone is bare of columbite.

The albite is the "curly" variety and is distinguishable from the microcline by its curly fracture. The microcline cleaves easily along well developed cleavage planes.

From 2-5ft. the felspar is mostly albite—the other minerals being muscovite (2in. to 3in. plates) and columbite. The columbite occurs in this zone in arrowheads and in rather a poorly developed crystal form. However, very little albite is intergrown with the columbite.

Up to 3ft. from the albite zone (i.e. 5ft.-8ft. from the hanging wall), good crystals of columbite of 1½lb. to 2lb. weight have been found in the microcline.

One of the characteristics of these columbite crystals is their well developed crystalline form. However, intergrowths of albite are a common feature in these crystals. This indicates that albitising solutions must have been responsible for the introduction of the columbite.

The pegmatite from 8ft. to the footwall is composed mainly of microcline with a little albite and with lenses of milky quartz.

Section CD shows a similar zoning to that of AB—except that the first 2ft. with microcline and tourmaline is "missing."

West of this line of section, the pegmatite narrows down to a width of 10ft. and less, and zoning is not marked. The pegmatite here is composed of both microcline and albite with a number of quartz lenses (? cores). Other minerals occurring are beryl (aquamarines, mostly small) some columbite and tourmaline. Biotite occurs in thin bands of fine flakes on the footwall.

North of the columbite workings, albite feldspar occurs with microcline on the surface, sloping to the east. This indicates that the surface may be (more or less) the hanging wall of a flatly dipping tabular pegmatite.

One notable feature of the main dyke is that there is practically no mineralisation apparent on the footwall. The only work done on the footwall side of the outcrop has been prospecting for eluvial minerals. This was singularly unsuccessful.

Thin bands of fine mica were observed at the contact of the pegmatite with the greenstone island at the north corner peg of MC 9. These bands, together with the mica bands already noted to the south west, are the only indications that any assimilation of the country rock, by the pegmatite solutions, took place.

Columbite.

Columbite is a member of the isomorphous columbite—tantalite series (Fe, Mn) (Nb, Ta)₂O₆. The series passes by insensible gradations from normal columbite, the nearly pure niobate, to normal tantalite, the nearly pure tantalate.

The columbite mined on MC 9 has a high percentage of niobium and little or no manganese. Analyses of two parcels shipped to London in June and July, 1951, showed Nb₂O₅ percentages of 68.50% and 65.52% respectively. Details:—

3 Drums Columbite/Tantalite, 7 cwts. 3 qrs. 2 lb.			
Assay:	Nb ₂ O ₅	68.50%	} 76.15%
	Ta ₂ O ₅	7.65%	
	TiO ₂	.70%	
	SnO ₂	.40%	

Price per unit, 317s. 6d., English currency.

8 Drums Columbite, 1 ton 1 cwt. 2 qrs. 14 lb.			
Assay:	Nb ₂ O ₅	65.52%	} 73.00%
	Ta ₂ O ₅	7.48%	

Price per unit, 265s., English currency.

Note.—Units are: 1% per long ton = 1 unit.

The columbite on MC 9 is won from two sources:—

(a) Lode.—Occurs on the hanging wall in the albite zones and adjacent microcline. It does not persist as a band along the strike but occurs rather as patches within the zones. The maximum width over which it has been seen to occur is 6 ft. Further columbite is probably hidden under soil cover to the north of the present workings.

(b) Eluvial.—Eluvial columbite has proved quite a good proposition where it has been worked—adjacent to the lode.

Prospecting for alluvial columbite downstream from the columbite workings proved unsuccessful. This is probably due to the high S.G. of columbite coupled with the low velocity of the stream.

Other Minerals.

Beryl.—(a) Lode: Occurs near some quartz masses but not all of them. It is often associated with the clear variety of quartz and is difficult to distinguish from the quartz. Both the clear and green varieties (aquamarine) of beryl have been found—mostly in small crystals (up to 3in. long). Odd crystals weighing several pounds have also been mined.

(b) Eluvial.—Floaters of beryl have been picked up in small quantities.

Quartz.—A few clear crystals of quartz have been found (near section line CD) and clear quartz veins occur. However, the dominant type is the bare milky variety.

Mica.—The mica is mainly muscovite and is too small and impure to have any commercial value.

Tourmaline.—Has no economic value. It is of the common black variety and is likely to be confused with columbite at first glance. However, it has a much lower S.G. and crystallises in a very characteristic form—making determination fairly simple.

Albite.—The soda feldspar is an aid in prospecting for columbite but has little commercial value.

Microcline.—This feldspar (potash variety) is very clean and should be worth shipment when sufficient quantities are mined out.

Recommendations for Development.

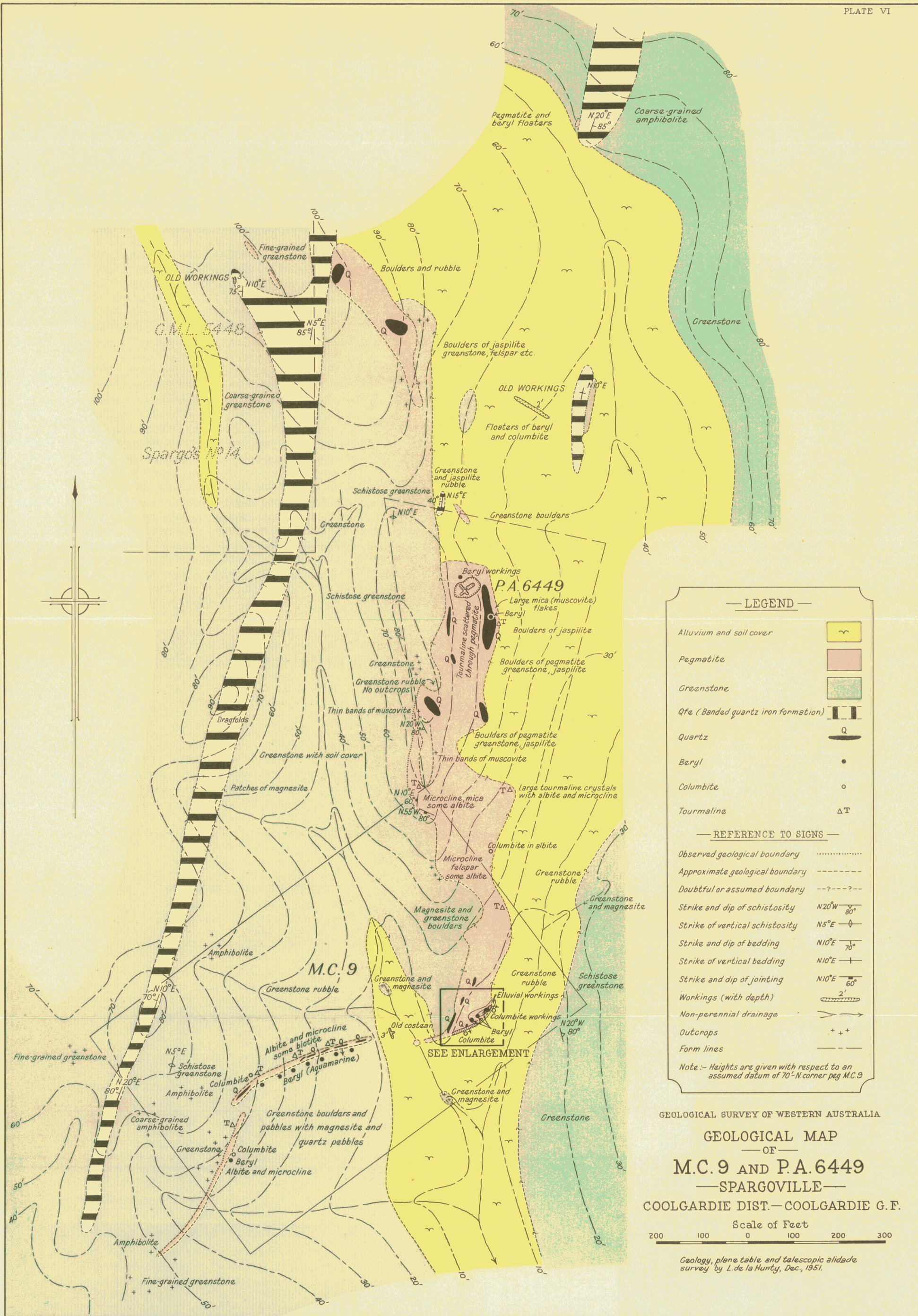
(a) Cut a series of trenches, 50ft. apart, across the approximate position of the hanging wall of the pegmatite—from the columbite workings northwards; i.e., across a line drawn from the present deep pit through the south corner peg of PA 6449.

Trenches dug east from this line should expose the hanging wall and will give a good idea of the amount of eluvial columbite in the overlying soil.

It is possible that the hanging wall may be up to 50 feet east of the present solid line of outcrop, and have a soil cover of up to 10 feet.

(b) If these trenches indicate good prospects, the hanging wall should be exposed along such length as appears promising.

(c) Since the columbite is patchy, within and adjacent to the albite zone, winzing, rather than driving, seems the best method of development at depth.



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„ —Glass	16	Wolfram	14
„ —Lime	17		
„ —Natural	16	Yeeda Station	31
„ —Silica	16		
„ —Synthetic	16, 17		